A

TREATISE

ON

ELECTRICITY.

The SECOND EDITION.

BY

BENJAMIN WILSON, F.R.S.

—Though every true ſtep made in this philoſophy brings us not immediately to the knowledge of the firſt cauſe, yet it brings us nearer to it, and on that account is to be highly valued.

Newton.

LONDON,
Printed and ſold by C. DAVIS in Holbourn, and R. DODSLEY in Pallmall. MDCCLII.

TO

The REVEREND

Granvill Wheeler Eſq.

Of *Otterden Place* in *Kent*.

SIR,

OUR knowledge of natural cauſes and effects can only proceed from experiments judiciouſly made, and faithfully related. Nature is no otherwiſe known than from trials made

upon herſelf, and while we advance in theſe trials, ſtep by ſtep, as ſhe leads the way, our reſearches generally prove juſt and accurate. It muſt indeed be owned, that our hopes are ſometimes diſappointed, but our very diſappointments frequently inſtruct; and by miſſing truth in one path, we often find her more eaſily in another.

THIS method of proceeding by experiment has of late years opened a large field of knowledge, and the proſpect wonderfully widens as we move forwards. Great diſcoveries have been made in this part of philoſophy;

losophy; but perhaps as great, or greater, remain still behind: and there seems full room left for farther inquiries.

ELECTRICITY is a part of experimental philosophy, hitherto the least inquired into; and however extensive in itself (perhaps no property of matter more so) has been so little cultivated, that a sufficient number of facts have not yet appeared, upon which its laws may be established. To investigate its laws, and from thence to deduce some certain principles of science, is the intention of the following Treatise, which

lays before you a great variety of experiments, moſt of them new, and ſome ſurprizing.

As whatever tends to promote uſeful knowledge, tends to advance the happineſs of mankind, any deſign of this nature, though imperfectly executed, cannot fail of meeting with your approbation. And beſides, there is no perſon, to whom a treatiſe on this ſubject can with more juſtice be inſcribed, than to him whoſe own reſearches, and whoſe incouragement and aſſiſtance to the late Mr. *Stephen Gray* gave riſe to thoſe extraordinary experiments, which have ſince excited

cited the curiosity of the Public to cultivate this part of philosophy. I am, with true respect and gratitude,

SIR,

Your much obliged,

and most obedient

humble servant,

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PREFACE.

WHERE there are many experiments which ſeem to point at ſome general principles in philoſophy, it is very difficult to avoid the temptation of becoming ſyſtematical. The following materials, in the hands of a *Newton*, or a *Boyle*, would probably have conducted them to the making of obſervations upon every experiment, and thence they would by induction have proceeded only to ſome general concluſions. For this method is recommended by the former, where the inveſtigation of difficult things is required. And it is certainly the moſt eligible: but this I was convinced of too late, nor have I had leiſure ſince the firſt publication, to put what I now preſent a ſecond time to the public into any other form.

One of my principal views has been to ſhew from experiment, that there is a very ſubtile fluid (call it by what name you pleaſe) which pervades all bodies; and is diffuſed throughout this whole globe, and its atmoſphere. Another, that in bodies of the ſame bulk, there ſeems to be more of it in light, than in heavy bodies. The former having more pores, or vacuities in them, than the latter. And further, that

that all bodies, under certain circumſtances, are capable of gaining, and actually do gain, a greater quantity of this fluid than they originally had. And on the contrary, all bodies, under certain other circumſtances are capable of loſing, and actually do loſe part of their original quantity of this fluid. Mr. *Franklyn* of *Philadelphia*, author of ſome very curious experiments on the ſame ſubject, diſtinguiſhes this difference by *plus* and *minus*.

I have likewiſe endeavoured to confirm what Sir *Iſaac Newton* ſuppoſed concerning a medium, being diffuſed over the ſurfaces of bodies, which he thought highly probable, as the phænomena of light were ſcarcely to be explained without it. And there is great reaſon to believe it is a principal agent in moſt of the effects in electricity.

In this edition ſome inaccuracies may ſtill have eſcaped me, which muſt be expected in a work of this nature, where there is ſuch variety of experiments, and thoſe ſo difficult to claſs in ſuch a manner as to form a regular ſeries. But though my ſucceſs herein has fallen very ſhort of my wiſhes; yet I hope that all the defects will be candidly overlooked and amended by ſome abler hand, who has more leiſure and abilities.

A TREA-

A
TREATISE
ON
ELECTRICITY.

PART I.

SECTION I.

IN the making of electrical experiments the effects produced are ſo very different, according to the different methods of performing theſe experiments, that we muſt carefully attend to the moſt minute circumſtances before we can hope to arrive at any certain knowledge of the laws by which electricity acts. To obtain this knowledge, the greateſt electric effects ſeem moſt neceſſary. We ſhall therefore give an account of the ſeveral circumſtances we have always obſerved requiſite for producing them: and afterwards ſet down the

ſigns by which bodies are known to be electrified; and how we are to judge of the different degrees of electrification. The machines, with which theſe kind of experiments are made, do not differ more in their conſtruction than they do in their power of electrifying. It may not be improper therefore firſt to give a deſcription of the machine with which the principal part of the following experiments was made.

A D H K repreſents a frame of wood two feet two inches long, and eighteen inches broad. The ſides of this frame are three inches by one and a half; and the diameter of the wheel F G, which alſo is of wood, fifteen inches. The axis of the wheel, E E, is ſo contrived, that it can be taken out and the wheel ſeparated from its axis, by which means they may be laid in the ſquare A M M H; it being large enough to hold not only them, but other parts of the machine. GG repreſents a glaſs cylinder with metal ends twelve inches long, and five in diameter. P, a pulley three inches diameter, fixed to one of the metal ends: round this pulley and the wheel F G is a cord or ſtring of catgut, which turns the cylinder round. The glaſs is rubbed by a cuſhion C, nine inches long and two broad, fixed to a ſpring S V, and made to preſs more or leſs againſt the cylinder by the ſcrew y, paſſing through a

croſs-

cross-bar of wood d d, fixed upon the upper-part of the frame AMMH. p, represents a small pulley of brass to tighten or slacken the string, by moving it higher or lower: and it is prevented from slipping lower by a small screw h. The same pulley also serves to keep the string from rubbing against itself when crossed, by turning the stem of metal in which the pulley is fixed a little on one side. w w, are several straight wires of *equal* lengths; one end of each is bent round, for the conveniency of hanging them on a thicker wire a a a. The wires may be raised or lowered by sliding it in the hole o, let into a bar of iron B B. This bar is supported by silk lines, L L L L, tied to the four pillars of wood 1, 2, 3, 4. The whole machine is fastened upon a table T T, by three hold-fasts with screws under the angles of the frame A D K.

As to the several circumstances that are necessary to be observed:

1. The cylinder should be five inches in diameter at least, and about twelve inches long.

If the cylinder be eight or nine inches in diameter, all the following experiments may be made with it; which is not the case with a less, for some experiments require a larger glass than others; as will appear hereafter.

We make uſe of a cylinder, becauſe from glaſſes of that ſhape, or oblong ſpheroids, which approach nearer to cylinders than ſpheres, we have been able to produce the greateſt effects. That cylinders or oblong ſpheroids are the moſt proper figures for this purpoſe, will be confirmed hereafter, not only from reaſon but experiments.

2. The cylinder muſt be of an equal thickneſs, or nearly ſo, if it can be had; and rather *thin* than thick, and of a good poliſh.

3. It muſt have no metal axis paſſing thro' it, unleſs the axis be covered with cement, wax, reſin, pitch, glue, or ſome other unctuous matter which is not ſoft.

4. It muſt be always freed from dirt and duſt, as well as from moiſture or dampneſs, before any experiment be made with it. To do the laſt more effectually, the looſe dirt, and that which ſometimes is found to ſtick very cloſe to the glaſs, being firſt wiped off, take a piece of clean dry flannel, and hold it near a fire till it be well warmed, then turn the wheel and rub the glaſs all over from end to end very well with it.

5. The cylinder muſt not be heated too much by continuing the friction of the cuſhion, but when an experiment has been made, let the turning of the wheel be diſcontinued for a little

little time, and the glaſs be rubbed again with the dry flannel, before a freſh experiment be made.

6. The cylinder muſt be in the ſame good order for electrifying equally ſtrong, before any experiment be begun to be made with it.

To do this more effectually the following farther cautions muſt be obſerved.

7. The cuſhion C muſt be about three inches ſhorter than the cylinder is long.

8. There muſt be a piece of clean ſmooth leather (red was what I made uſe of) of a conſiderable length, and as broad as the cuſhion C is long; this leather muſt be moiſtened with a wet ſponge from time to time on the rough ſide, and afterwards, the dry ſide muſt be warmed a little by the fire; when this has been done, and the dry ſide well wiped, to free it from duſt and moiſture (there being an oily matter brought out of the leather by heating it) place it between the cuſhion and cylinder, with the dry or ſmooth ſide to the glaſs.

N. B. If the leather be gilt or covered over with ſilver, braſs, or copper, and the metal ſide applied to the glaſs (the other ſide being alſo moiſtened with water) it will do full as well.

9. The edges of this leather muſt not turn up towards the cylinder; this may be pre-

vented by rolling it up, or turning it back; or letting a ſmall weight hang to it.

10. Different preſſures of the cuſhion againſt the cylinder will produce very different effects, therefore the preſſure ſhould be *uniform*, and rather ſtrong than otherwiſe.

11. The wheel muſt be turned always the ſame way, ſo that the cylinder muſt turn towards the points of the wires w w, that is from C towards w w and m, and not from C towards m and ww. Thoſe points w w muſt hang cloſe to the glaſs, and about three and a half or four inches from the cuſhion.

12. The wheel muſt be turned uniformly quick, and not faſter in one experiment than another (ſuppoſe thirty or forty turns in a minute) unleſs where it is mentioned to the contrary.

13. The bar BB muſt be an inch and an half or two inches in diameter, and the ends rounded off hemiſpherically, unleſs we mention the contrary.

14. The ſilk lines L L, on which it hangs, muſt be of the thickeſt ſort, and ſix inches long at leaſt, and quite dry, and free from duſt and dirt. As to the colour of the ſilk lines, let them be red or yellow.

15. Metal bodies, and ſuch as will be particularized hereafter by the name of non-electrics,

ctrics, that are to be electrified, must be free from dust and dirt, and must have no edges, corners, or points; nor must wires or strings be made use of (for they approach towards edges or points in some degree, by reason of their smallness) unless at any time we desire the contrary.

16. No points, corners, or edges, or small non-electric bodies must be any where near the body to be electrified, or the cylinder G; except those points w w hanging to the side of the cylinder.

17. All non-electrics should be above eighteen inches at least, and points, corners, and edges, three feet at least, distant from the body to be electrified, or the cylinder G: unless they are placed on such bodies as will hereafter be distinguished by the name of electrics: and even then points, corners, and edges of non-electric bodies must be avoided, except the contrary be mentioned.

18. No flame, smoke, or steams, must be near the machine.

19. The air must be dry, and freer from sulphur than it generally is, when the days or evenings are very warm.

20. The top of the table on which the machine is fixed, as well as the machine itself, must also be freed from dust.

21. The table muſt ſtand on moiſt ground, or if the table be in a chamber, a wire paſſing from the machine to the moiſt ground will do full as well.

22. When we mention *wax*, it is with indifference, for either glaſs, reſin, pitch, glue, ſilk or hair, do as well.

23. Common bees wax of itſelf is too ſoft: therefore a quantity of reſin (half as much, or more) ſhould be diſſolved in it, which will make the mixture, when cold, much harder and fitter for uſe.

24. When either wax, reſin, pitch, glue, glaſs, hair, or ſilk lines are made uſe of, we always ſuppoſe them very dry, and freed from duſt and dirt; and the five firſt to be ſix inches thick, and the two laſt to be ſix inches long at leaſt, unleſs the contrary be mentioned in any experiment.

25. When a body is to approach, or be brought near an electrified body, we always ſuppoſe theſe three things to be carefully obſerved. Firſt, that the approaching body be in contact with the earth at the ſame time. Secondly, that the approaching part be a rounded ſurface (a quarter of an inch at leaſt in extent) free from points, corners, or edges. And laſtly, that it be moved towards the electrified body, not ſlowly, but very quick: unleſs at any

any time the contrary of any of these things be mentioned. If the electrified body be the approaching body, we suppose it to be moved towards the other also very quick.

26. Before a fresh experiment be made with the same body, we always suppose no signs of its being electrified remaining.

27. If a person should rub the glass with his hand instead of the cushion, we suppose it to be in the same place where the cushion is placed, and with the same pressure, with respect to the signs by which bodies are known to be electrified.

The cylinder G, or bar B B (or any other body) is said to be electrified when light bodies of any kind are moved to and from any part of the cylinder or bar. And when two or more very light or flexible bodies of any kind, placed near one another, and in contact with any part of the cylinder or bar, are made to recede from one another by rubbing the glass only, the cylinder or bar is also electrified.

Again, the bar is likewise said to be electrified when an explosion and painful sensation happens, on a person's approaching any part of it with any part of his body. Or when an explosion happens on the approach of any non-electric body towards the bar.

The

THE different methods to determine the degree of electrification under certain circumstances, as accurately as we are able, are as follow:

1. WHEN a body is electrified, observe the time it will take up before all signs of electrification cease: the longer the time is, the degree of electrification will be the greater.

2. WHEN a body is electrified, observe the distance at which light bodies are moved towards it, and at what distance it will electrify another body, the greatest distance is a sign of the greatest degree of electrification.

3. WHEN two light bodies are suspended in threads, and electrified, observe how far they will recede from one another: when they recede the farthest, the degree of electrification is the greatest.

4. WHEN a body is electrified, observe to what degree that body is capable of electrifying another body which is brought near it, both being suspended in silk lines, or laid on wax, resin, or glass: the more the first electrifies the other body, the degree of electrification in it will be the greater.

5. WHEN a body is electrified, and approached by another which is not electrified, to cause an explosion, approach it a second time, and repeat the approaches till no more ex-

explosions ensue, observe their number, their degrees of *light* and *loudness* at each approach. The greatest number of explosions attended with the greatest degrees of light and loudness, are signs of the greatest degree of electrification.

6. When a light is seen to issue from the body electrified, supposing the body somewhat pointed, and the room dark in which the experiment is made, and this light does not appear larger and brighter by continuing the electrification, that body is not capable of being electrified to a greater degree.

7. The method commonly used to electrify bodies to the same degree, is to turn the wheel an equal number of times with the same velocity: the pressure of the cushion C being always supposed the same, and the glass in the same good order for electrifying equally well, as we have taken notice of before.

SECTION

SECTION II.

EXPERIMENT I.

IF the cylinder of glaſs G (fig. 1.) be rubbed by the cuſhion C, the bar of iron BB with the wires w w, being ſuſpended near the glaſs on ſilk lines L L, a perſon, upon approaching the bar BB with his hand, will perceive a luminous ſpark to iſſue, accompanied with a ſnapping noiſe, and a ſmart ſenſation; and light bodies, placed at ſmall diſtances, will be moved to and from the bar.

IT appears from this experiment that friction is neceſſary to cauſe theſe phænomena; for without rubbing, the cylinder will not produce theſe effects.

THE matter cauſing ſuch effects we ſhall call *electric matter:* and the giving this property to bodies, *electrifying*.

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EXPERIMENT II.

WHEN the bar BB is electrified, and a finger or piece of metal moved towards it as was done in the experiment, after an exploſion the electric matter (or the greateſt part of it) will be found to have deſerted the bar; for a ſecond

cond effect, equal to the firſt, cannot be produced till it is again electrified. Whereas if the bar, when electrified, be approached with glaſs, amber, wax, pitch, or glue, there will be no exploſion; and the electric matter, or a conſiderable part of it, will be found to continue ſtill in the bar; for if the finger or metal be applied immediately, there will be an exploſion, and the ſame effects produced as at firſt.

EXPERIMENT III.

IF a perſon P ſtands upon glaſs, wax, reſin, or glue R, and takes hold of the bar BB, upon being electrified, he will be found to retain the electric matter in like manner as the bar. If the perſon P ſtands on any of the ſame kind of bodies as wax, reſin, glue, or glaſs, that are very thin, he will retain the electric matter in ſome degree, but not ſo ſtrongly as in the other caſe. And if the perſon P does not ſtand upon any ſuch bodies, but on the floor or earth E, and takes hold of the bar BB as before, neither he nor the bar, will appear to be electrified.

FROM the ſecond and third experiments, it appears that the electric matter does not paſs ſo readily through glaſs, amber, wax, reſin, or glue, when ſuch bodies are of a proper thickneſs, as when the ſame kind of bodies are thin: but the electric matter appears to paſs through metals

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metals and animal bodies, of all magnitudes. And since in the latter part of the third experiment there is not the least appearance of electric matter within the person, or bar, and there is in the first part of the same experiment, the electric matter must be diffused and lost in the earth.

It also appears that metals, when rubbed in like manner as glass, cannot electrify any other body: for if we suppose that the electric matter was by friction brought to, or excited in them, yet it would immediately pass away by them.

Experiment IV.

If the widest end of a small glass syphon be immersed in a metalline vessel filled with water, and suspended on the bar; on turning the wheel the water will be electrified, and during the turning of the wheel, the water will in running out at the narrower end of the syphon spread to a much greater distance than if the water was not electrified, or the turning of the wheel was discontinued. And if upon ceasing to turn the wheel, a non-electric body be brought towards the end of the syphon before the electric matter be intirely dissipated, the water will again spread, but not to so great a distance as when the wheel is continued turning.

Expe-

EXPERIMENT V.

If a person standing on wax, resin, glue, or glass, takes hold of, and thereby becomes as it were a part of the bar or body to be electrified; or if a large quantity of iron, lead, copper, or any other metal, be set upon any of the above bodies, wax, resin, glue, &c. in the place of the person, and communicates with the bar, upon electrification, the effects will be the same, whether you approach any part of that person, or the bar, or body electrified; that is, there will be an equal explosion from any part of the person or the metal. And if the person electrified approaches any part of his own body, or any other body that is *equally* electrified with himself, there will be no explosion.

It appears from the fourth and fifth experiments, that when a quantity of electric matter is communicated to any of those bodies (every part of which is supposed equally capable of receiving it) the same matter diffuses itself equally throughout that body, and is consequently *fluid*.

EXPERIMENT VI.

Let all the apparatus be placed upon cakes of wax, resin, glue, or glass, so that all communication between the earth and the apparatus be cut off, the bar B B will not be electrified

fied in ſo ſtrong a manner, after a few turns of the wheel, as in the other experiments.

From this experiment it appears (ſince there is no other change of circumſtances in making it, except that the communication between the machine and the earth is cut off) that the electric matter comes from the earth, and is collected, not produced by the apparatus.

That it is capable of paſſing through ſome bodies, and not through others.

The former of theſe bodies are called *non-electric*, the latter *electric* bodies.

It ſeems upon the whole of this ſection, as if the electric fluid were diffuſed throughout all bodies (at leaſt non-electrics) on, or near the ſurface of the *earth*, as well as the body of the earth itſelf.

SECTION III.

When bodies are electrified, we ſuppoſe they have received an additional quantity of electric matter, and in ſuch circumſtances the electric matter may be ſaid to be *accumulated*.

Experiment VII.

When two threads of equal lengths are hung cloſe together, and ſo as to touch the body

body to be electrified, they will recede further and further from each other, as the body is higher and higher electrified. And the higher the body is electrified, the longer it will be before all the electric matter be dissipated and lost.

If the electric matter passed out of the threads as fast as it entered them, the threads could not recede from one another more or less, as they are more or less electrified; so that something must in part obstruct or hinder its passing out: and if the electric matter passes faster in than it does out, which is here the case, there must be an accumulation; therefore the distance of the threads will be greater or less, as the accumulation of the electric matter is more or less increased: and if it be more or less increased in the threads, it must also be so in the bar. The truth of this is manifest from the effects.

EXPERIMENT VIII.

If a sphere of iron three feet in diameter, and a sphere of the same metal three inches in diameter, be placed upon separate bodies of wax, and electrified at the same time by the bar BB, light bodies will not be moved towards the larger sphere from a greater distance than towards the lesser sphere. But if whilst they are electrified, both of them be immediately re-

moved at the same time from the bar, the larger sphere will retain its electric matter longer than the lesser sphere.

From the latter part of experiment the fifth it appears, that non-electric bodies of the same kind are equally electrified, when they are in contact with the electrifying body. Therefore the two spheres in the above experiment are equally electrified. The quantities of matter in these spheres are very different, and the times of continuing longer electrified are likewise different; consequently the quantity of electric matter contained in each must be different. But the power of moving light bodies to and from them, is the same in both bodies whilst they are in contact with the bar, or at the instant of removing them from the bar; and of consequence does not depend upon the quantity of electric matter; but will be always the same, supposing the fluid collected equally dense. This is the case with water and air (provided the density of the air be the same in different spaces) wherein the resistance made to a body falling will be the same, whether the quantity of water or air be greater or less. But the effects of moving of light bodies, and of continuing longer electrified (as well as the magnitude of the explosion) however, will be different, as the quantity of electric matter in any

any given quantity of matter differs: or, in others words, will be in proportion to the different density of electric matter, by experiment 7. Since then, this fluid is capable of being made more or less dense, as a greater or less quantity may be included in the same space, it is therefore *elastic:* and since it is elastic, the more it is compressed, with the greater force it will restore itself: and consequently with the greater velocity.

Experiment IX.

If two bodies x and y (fig. 4.) [a] of equal or unequal magnitudes, but equal densities, suppose two globes of iron, the first electrified, the other not, are placed or suspended at a given distance from each other upon electric bodies, or silk lines L L, and afterwards x be made to approach y, or y x, the quantity of electric matter will be lessened in x, and that in a different proportion as the bulk of the body y is greater or less.

For if x be electrified, and of equal magnitude and density with y, and the former be brought near the latter, the effects of the one and the other will be found equal: if y is greater than x, their effects will be still equal, but weaker, than in the other case: because of

[a] Mr. *Watson* published an experiment of this kind in his *first Essay on Electricity*.

the electric matter being expanded in a larger ſpace, or a larger quantity of matter. And therefore if y was a ſphere of one thouſand feet in diameter or more, and x one foot only, the effects would become inſenſible: even tho' the whole quantity that was accumulated in x ſhould be diffuſed in y: as may be gathered from comparing the cubes of thoſe diameters.

COROLLARY.

HENCE it follows, that the elaſticity of the electric fluid is leſſened in proportion as it is rarified. And hence alſo, we may eaſily conceive how the *earth* may conſtantly have this matter diffuſed *every where within it*, and yet the effect not ſenſible, till it is collected in greater quantities in any particular body.

EXPERIMENT X.

IF a long wire be extended, and ſuſpended in ſilk ſtrings, that are tied to ſtakes fixed in the ground (to prevent the wire from being near the earth or other non-electrics) and afterwards be electrified: the longer the wire is, the greater will be the effect, or painful ſenſation, upon cauſing an exploſion, by a perſon's approaching the wire.

IT has been already ſhewn (by experiment eighth) that effects apparently equal (ſuch as moving of light bodies from certain diſtances, and repelling them again) will always be produced

duced by unequal quantities of the electric fluid, provided the densities of the fluid be the same. But when the density of the one exceeds the density of the other, the difference of the effects are as that excess (by experiment seventh) the greater then the excess of density is, with the greater force, or velocity, it must endeavour to restore itself; consequently the greater will be the effect or painful sensation.

But, *cæteris paribus*, the longest electrified body gives the greatest effect, such as the explosion or painful sensation; therefore the electric matter must move with a greater velocity through a long body electrified, than through one that is shorter. For if the same wire be twisted in a heap together very close, the sensation and explosion will be *much* weaker.

EXPERIMENT XI.

If the electric matter be communicated to a wire (suspended as in the last experiment) two or three miles in length (and it is not easy to make the experiment with a greater length) the effect will be perceived at the further end from the machine (by moving too and fro light bodies placed near that end) as soon to all appearance, as at the end nearest the machine: and if both ends of the wire be approached as near as possible at the same time, the electric matter will be only seen to issue from one of

them, viz. from that which is soonest approached.

QUERY I. Whether such propagation may not be owing to the elasticity of the electric matter? If so, the elasticity thereof, in proportion to the quantity of matter it contains, must be vastly greater, than that of any other elastic body or fluid we are acquainted with.

SECTION IV.

PROPOSITION I.

IF the surface of a non-electric C (pl. I. fig. I.) be applied to the surface of an electric body G, and the one be agitated by the motion of the other, a quantity of electric matter contained in one or the other, or both of them, will be excited: which quantity will be conveyed to the next adjacent non-electric body whose parts are not agitated, where it will be continually dissipated; unless the adjacent body be separated from other non-electrics by the interposition of electrics, in which case the electric matter will be retained, and accumulated therein.

THE cushion, in this proposition, is the non-electric represented by C; G is the glass cylinder, or the electric body; from the action of

of thoſe two, the electric matter is produced by their rubbing or preſſing againſt each other, the glaſs G being turned ſwiftly round: B B is the bar of iron (including the wires w w) which is the adjacent non-electric body not agitated [a], and L L are the ſilk lines, or the interpoſed electrics, to prevent the electric matter from diſſipating by them [b].

The truth of this propoſition will appear from the firſt experiment, as well as from all the methods hitherto found out of accumulating the electric matter in non-electric bodies.

If the propoſition be not ſufficiently proved,

Turn the wheel the contrary way, ſo that the rubbed parts of the glaſs cylinder may paſs by the edge of the frame of the machine m, before they come to the wires w w; and the bar will appear to be electrified in a leſs degree. Lay a number of wires, ſuch as theſe marked w w (that hang againſt the cylinder) on the frame with the points or ends towards the glaſs, then continue to turn the wheel ſtill the ſame way, and the bar will appear to be electrified in a much leſs degree, But turn the wheel the other way and the bar will appear to be as ſtrongly electrified, as in experiment firſt, ſection ſecond.

[a] Mr. *Steph. Grey* made the diſcovery of electrifying non-electric bodies. See the *Phil. Tranſ.* N° 417.

[b] It is to Mr. *Wheeler* we owe the diſcovery of ſilk lines, for he propoſed them firſt to Mr. *Grey*.

PROPOSITION II.

SUPPOSING the bodies to be in other respects, as in proposition first, but the adjacent non-electric one B B, which is there not agitated, to be put into an equal agitation with the other two, C and G; in that case, the adjacent non-electric body B B will appear to be but little, or not at all electrified.

EXPERIMENT.

LET [a] the glass cylinder G (fig. 1.) (which in this experiment we suppose ten inches at least in diameter) be excited to electricity by means of C, or by a person standing on the floor, applying his hand to one side of it; whilst another person standing on wax, or resin, applies his hand in the place of the iron bar B B or the wires w w (they being taken away) and rubs that opposite side of the glass, in the opposite part g, at the same time, with a pressure against G as nearly equal to the pressure of C as can be judged. In such circumstances, the person standing on the wax will be but little, if at all electrified. But let him apply his hand to the glass *lightly*, or the ends of his fingers only, and he will then, without any other alteration, be strongly electrified.

[a] This experiment was made by Mr. *John Smeaton*, the inventor of a new and very curious air-pump, which rarifies the air a thousand times, and by turning a cock the same becomes a condenser.

PRO-

PROPOSITION III.

WHEN a body has *lost* any part of its original quantity of electric matter, or has *gained* an equal part, over and above what it originally had, in both these cases the electric effects, such as the explosion, and the motion of light bodies towards it, will be the same. In the first case, these effects are produced by its gaining a quantity equal to that which it had lost, and in the second case, by its losing a quantity equal to that which it had gained.

EXPERIMENT.

LET the person who turns the wheel and the machine itself M (fig. 2.) be placed upon electrics at some distance from all other non-electric bodies, excepting the suspended bar BB, including the wires w w, which bar in this case must have a free communication with the earth, by letting some non-electric N touch it and the earth. Then if after a few turns of the wheel, the wheel being still continued turning, another person approaches any part of the frame of the machine M, or the person who turns the wheel, an explosion will be perceived in like manner as if the same were electrified; and light bodies, placed at certain distances from the machine or the person

son turning the wheel, will also be moved towards them.

Now if, in this experiment, the machine and person have really lost part of their original quantity of electric matter, and any of the bodies in the first, third, fourth, fifth, seventh, eighth, ninth or tenth experiments, have really gained an equal part over and above what they originally had, then the proposition is true. For whenever the *equilibrium* in air is destroyed by any part of it being rarefied or condensed equally, that *equilibrium* will be soon regained. Now what is true of air, which is an elastic fluid, may be supposed to hold good in regard to the electric matter, which seems to be a fluid similar to air as to its elasticity.

PROPOSITION IV.

Non-electric bodies, under certain circumstances, actually lose part of their original quantity of electric matter.

Experiment.

Let the whole apparatus be placed as in the last experiment, except the bar BB (fig. 2.) which is now to have no communication with the earth (the non-electric N being taken away) when the bar has been electrified, and the matter discharged by two or three explosions, it cannot be electrified afresh to an equal

equal degree, without opening a communication between the earth and the machine M, or setting another quantity of non-electric matter [a] which is not electrified, upon the machine M, or ceasing to turn the wheel for a time. The machine then must have lost some part of its original quantity of electric matter, as it no longer retains a power of electrifying the suspended bar. But let the suspended bar BB be held by the hands of one, two, three, or more persons standing upon wax, or let there be other large quantities of non-electric matter 1, 2, 3, and placed in the same circumstances, and the machine M will appear to have lost a yet greater quantity; which loss will appear to increase as the numbers increase in arithmetical proportion, to a limited degree, or in other words, as the quantities of non-electric matter added are greater, to a limited degree.

One of these suppositions must be true, viz. that the machine is electrified in like manner as the suspended bar, and receives the electric matter from without; or else such matter is contained in the machine itself, and excited into action by means of friction. Now if the machine receive the electric matter from with-

[a] The non-electric matter to be set upon the machine, must be brought to it by means of electric bodies.

out,

out, it must be either from the surrounding atmosphere or the earth. The first cannot be the case, for supposing it was, the effects produced would be the same how ever the machine was placed; upon condition only that it was placed in the open air: nor can the latter be true, since by supposition, in the preceding proposition, all communication is intercepted between the earth and the machine, the electric matter then must be contained in the bodies themselves. And that part of this accumulated electric matter in the bar is dissipated upon an explosion is manifest, since after two or three explosions made, it is not in our power in the circumstances described in the above experiments (how long soever the same friction be continued) to cause an equal number of explosions equally strong from the bar afresh; and therefore we may conclude, that it does not issue from the glass but from the machine itself; for if that was supposed, an open communication between the earth and machine ought to make no difference.

When the machine and person turning the wheel cease to electrify the suspended bar of iron B B, some gentlemen have thought the machine itself and person turning it may be electrified, and by virtue of the whole being in a repulsive state, the electric matter cannot

not paſs out of them into the bar: but this ſuppoſition does not appear to be true, as may be gathered further from the following experiments.

EXPERIMENT I.

LET two pieces of thiſtle-down be tied to ſeparate threads two or three inches long, and thoſe threads be afterwards tied to one end of a ſilk ſtring fifteen or twenty inches long, upon bringing them towards the bar, whilſt the wheel is continued turning, and the machine in contact with the earth, the fibres of the down will ſtand at a diſtance from each other, and from the bar, and be ſtretched out in many directions: whence we may ſafely conclude, that the quantity of electric matter ſurrounding any part of bodies electrified to ſome diſtances, cauſes the parts which are free and at liberty (and ſuch are the pieces of down and their fibres) to reced from one another and the bar; in like manner as the threads in the ſeventh experiment, ſection third. If any non-electric body be held near the pieces of down whilſt they are in the above circumſtances they will be moved towards the non-electric, and immediately after towards the bar, then back again, and ſo on continually, and very quick, whilſt the bar is continued to be electrified.

EXPE-

Experiment II.

On the contrary, instead of holding the pieces down towards the bar, let them be held towards the frame of the machine or the person who turns the wheel (the machine and person turning the wheel, being now set upon wax) and one of the pieces of down will be moved towards that part of the person or the frame of the machine it is nearest to; and the down will continue to touch it, whilst the other piece will be stretched out towards the nearest non-electric, which is in contact with the earth. And if a non-electric body be brought in like manner equally near the last mentioned piece as in the other experiment, there will be no such appearance as that of their being moved too and fro between the bar and the non-electric body. But on the contrary, the pieces of down will be extended between the non-electric and the bar, and continue so, whilst the wheel is continued turning.

Experiment III.

Again, if the machine and person be electrified in like manner as the bar (by another machine) upon holding the pieces of down as in the second experiment, they will be moved too and fro between the machine and the non-electric, in like manner as they were between the bar and the non-electric in the first

experiment. If a non-electric approach any part of the frame of the machine, as in the second experiment there will issue an explosion equal (if not greater) to that when the same body approaches the machine in like manner as in the third experiment, or the bar in the first experiment. Now since nearly similar effects, with respect to the explosion, are produced in the first, second, and third experiments, and at the same time quite opposite effects, with respect to the repulsive power; there being no signs of the electric matter being accumulated either in the machine, person, or the pieces of down in the second experiment; the machine and person in the second experiment, are neither of them electrified: or in other words, the machine and person have not received a greater quantity of electric matter than originally belonged to them, but on the contrary have lost part of their original quantity of electric matter.

N.B. When a body has lost any part of its original quantity of electric matter, in such circumstances the electric matter in that body may be said to be *attenuated.*

COROLLARY I.

From hence it follows, that a free communication with the earth is necessary to cause and continue an accumulation of electric matter

ter in non-electric bodies; friction alone not being sufficient.

COROLLARY II.

HENCE also the explosion and sensation will be greater when a person electrified touches any body whose original quantity of electric matter is made less or attenuated, than when the same person touches any body whose original quantity is neither attenuated, or made greater: which effect is quite opposite to that mentioned in the latter part of the fifth experiment, section second.

PROPOSITION V.

THE original quantity of electric matter in a non-electric body, in certain circumstances, cannot be *attenuated*, or made less in that body, beyond a certain degree.

EXPERIMENT.

LET every circumstance be the same in this experiment as it was in the experiment following the third proposition, and then cause the wheel to be turned as before, after a number of turns of the wheel (suppose forty) light bodies will be moved towards the machine from a certain distance: and if any part of the machine be approached by a non-electric, there will ensue a certain explosion: continue the friction for any length of time, and these ef-

fects will not differ; that is, light bodies will not be moved from greater diſtances, nor will the exploſion be larger.

PROPOSITION VI.

THE electric matter cannot be *accumulated* in a non-electric body beyond a certain degree, in certain circumſtances.

EXPERIMENT.

LET the bar B B, or any other non-electric body, placed on wax, or reſin, or ſuſpended by ſilk lines, be electrified by a few turns of the wheel; and a light body will be moved towards it from a certain diſtance, and if two threads are electrified, as in the ſeventh experiment, ſection 3, they will recede from one another to a certain diſtance; continue the electrification for any length of time, and there will be no apparent difference; that is, a light body will not appear to be moved towards the bar from a greater diſtance, nor will the threads appear to recede further from one another, neither will the exploſion be any larger when the bar is approached by a non-electric.

SECTION V.

PROPOSITION. VII.

THE accumulation of electric matter in a non-electric body, in *some* circumstances, seems to be directly proportional, and in *other* circumstances reciprocally proportional, to the resistance it meets with as it tends to expand and dissipate; provided that in each case the resistance does not exceed a certain degree.

EXPERIMENT I.

WHILST the wheel is turning, and the bar BB (which is now supposed pointed at each end) constantly electrified, a light will be seen to issue from the extremities thereof; and if one of the extremities has a finer point than the other, the light will issue most copiously from that point; but there will be no such appearance in any part of the surface of the bar: nor will the bar be electrified to a greater degree, though the friction be continued ever so long. On ceasing to electrify the bar, that instant (to all appearance) the light at the point ceases; and if a person brings a non-electric near the point, the light will again issue for a very short time, after which there will be no appearance of electric matter remaining in the bar.

EXPE-

Experiment II.

If the bar be cylindrical, and an inch and an half, or two inches in diameter (which we have ſuppoſed all along) and have one of its ends rounded evenly off, on electrifying it, there will iſſue a light from that end only which is pointed, and the bar will be ſomewhat more ſtrongly electrified.

Experiment III.

If the pointed end of the bar be alſo rounded evenly off, in like manner as the other end, there will be no appearance of light either from the ſurface or thoſe rounded extremities; and if the wheel ceaſe from turning, the bar will continue longer electrified, than in either of the two laſt experiments: ſo likewiſe the exploſion will be larger, and louder; and conſequently, the bar will be more ſtrongly electrified, than in either of the two laſt experiments: which degree of electrification can never be made greater by continuing the turning of the wheel.

Observ. I. From theſe three laſt experiments it appears, that points reſiſt the exit of the electric matter leſs, than ſurfaces; and that the bar, in the ſeveral circumſtances mentioned in thoſe three experiments, is not capable of receiving a greater quantity of electric mat-

ter, than what is produced by a few turns of the wheel.

EXPERIMENT IV.

If the finest pointed needle that can be had (or any other angular termination, or edge of a non-electric body equally fine) be held at some distance, suppose eighteen inches, or thereabouts, from the bar, by a person standing upon the earth with the point towards the bar, whilst the bar is electrifying, light bodies will not be moved from so great distances towards the bar, nor will the explosion be so great on a person's touching the bar with his finger, as when the needle is taken away.

EXPERIMENT V.

Move the point of the needle nearer the bar (the electrification being continued) and these effects will be more apparent; that is, light bodies will not be moved from so great distances, nor will the explosion be so large as in the last experiment.

EXPERIMENT VI.

If the point of the needle touches the bar, light bodies will not appear to be moved towards the bar, though placed very near the bar. And if the bar be approached by a piece of metal, or the finger of a person, no explosion will ensue.

OBSERV.

Observ. II. From the fourth, fifth, and ſixth experiments it appears, that the electric matter diſſipates faſter, the nearer pointed bodies (or other edges or angular terminations of non-electric bodies equally fine) are brought to bodies electrified.

Experiment VII.

If inſtead of the needle point, the end of a body which has no point, or ſharp edge, ſuppoſe the head of the needle, or the end of a thick wire, evenly rounded off, be oppoſed towards the bar at the ſame diſtance the point was oppoſed in experiment the fourth, light bodies will be moved towards the bar from much greater diſtances than thoſe mentioned in that experiment: and the exploſions from the bar will alſo be greater.

Experiment VIII.

Move the end of the wire, or the thick end of the needle, conſiderably nearer the bar, and then the effects will be nearly the ſame with thoſe mentioned in the fourth experiment.

Experiment IX.

If the end of the wire, or the thick end of the needle be ſtill moved nearer, till it be in contact with the bar, the effects to appearance will be the ſame with thoſe mentioned in the ſixth experiment.

Observ. III. From the ſeventh and eighth experiments, compared with the fourth and fifth experiments, it appears that the electric matter in the bar is diſſipated faſter by the approach of bodies finely pointed, than of bodies that are rounded off, or have not points equally fine when oppoſed at equal diſtances. But when either kind of bodies is in contact with the bar, the effects are the ſame.

Experiment X.

If a much larger ſurface than the end of the wire, or the edge or angular termination of any other non-electric body, equally blunt, be oppoſed at the ſame diſtance from the bar as mentioned in the fourth experiment (ſuppoſe the head of an iron poker) which is round and large, on electrifying the bar again, the exploſion from the bar, on a perſon's approaching it with a piece of metal, or his finger, will, to all appearance, be the ſame as when when the poker is taken away intirely; ſo alſo light bodies will be moved from equal diſtances, whether the poker be held there or not; nor will there be any difference if the palm, or back of a perſon's hand, or any other larger ſurface be oppoſed at the ſame diſtance.

Experiment XI.

Move the end of the poker, or the ſurface of the hand, half way nearer towards the bar,

that is, about nine inches, and the difference, whatever it may be, will not be perceivable.

EXPERIMENT XII.

But move either of them considerably nearer the bar; and there will be a difference; which difference (at a proper distance) will be the same nearly with that mentioned in the fourth experiment.

EXPERIMENT XIII.

If either of them be in contact with the bar, the effect to appearance will be the same with those mentioned in the sixth and ninth experiments.

Observ. IV. From the tenth, eleventh, and twelfth experiments, and the fourth, fifth, seventh and eighth experiments, it appears that the electric matter in the bar is not dissipated so fast by opposing large surfaces at some distance from the bar, as by opposing lesser surfaces at the same distance. And from the sixth, ninth, and thirteenth experiments it appears, that the electric matter in the bar is dissipated equally fast (to appearance) in each experiment when the bodies are in contact with the bar.

EXPERIMENT XIV.

If the person holding the needle (or any other angular termination, or edge of a non-electric body equally fine) stands now upon a thick cake of wax, with the point of the nee-

dle towards the bar, at the same distance with that mentioned in the fourth experiment; on electrifying the bar, the person holding the needle will be electrified also, but not to an equal degree with the bar; as appears from another person's approaching each of them separately with his finger: there issuing a larger explosion from the bar, than from the person who stands on the wax.

EXPERIMENT XV.

IF the point be moved nearer the bar, the person then will be more strongly electrified, but not yet to an equal degree with the bar.

EXPERIMENT XVI.

IF the point be in contact with the bar, then the bar, needle, and person, will all appear equally electrified.

OBSERV. V. From the fourteenth, fifteenth, and sixteenth experiments, it appears that the electric matter passes by the needle into the person holding it: consequently, if the person did not stand on wax, the electric matter would pass, and be dissipated in the earth by experiment third, section second, as well as by the sixth, ninth, and thirteenth experiments in this proposition.

EXPERIMENT XVII.

IF instead of the point the person turns the thick end of the needle, or wire, towards the

bar,

bar, but at an equal diſtance from it with that mentioned in the fourth or fourteenth experiments, he will not be ſenſibly electrified.

EXPERIMENT XVIII.

MOVE either of them conſiderably nearer the bar, and he will be electrified in a ſmall degree.

EXPERIMENT XIX.

LET the thick end of the needle or wire be in contact with the bar, and the bar, wire, and perſon, will appear equally electrified, and to the ſame degree with the ſixteenth experiment.

EXPERIMENT XX.

IF, inſtead of the wire, the poker be oppoſed at the ſame diſtance as mentioned in the fourth or fourteenth experiments, the perſon holding it will not be electrified.

EXPERIMENT XXI.

LET him move it half way towards the bar, that is, nine inches, ſtill there will be no appearance of electric matter in the perſon.

EXPERIMENT XXII.

IF he moves it nearer the bar, he will be electrified, but in a leſs degree than the bar.

EXPERIMENT XXIII.

IF the poker be in contact with the bar, the bar, poker, and perſon holding it, will be equally electrified; which in this reſpect is the ſame

ſame with the ſixteenth and nineteenth experiments.

Observ. VI. From theſe laſt experiments it appears, that large ſurfaces reſiſt the *entrance*, as well as the *exit* of the electric matter more, than leſſer ſurfaces; ſuch as points, edges, and angular terminations. And therefore from the whole of theſe experiments it ſeems, that the accumulation of electric matter in bodies, in certain circumſtances, is directly proportional to the reſiſtance it meets with as it tends to diſſipate.

We are now to ſhew, that in other circumſtances the accumulation of electric matter is reciprocally proportional to the reſiſtance it meets with as it tends to diſſipate.

Experiment XXIV.

Take a clean dry thin vial V (fig. 5.) which will hold about a pint, or more, and fill it with filings of iron, or water; then put a cork into the neck of it, and puſh a thick wire w thro' the cork into the vial amongſt the filings (if water be made uſe of the wire muſt touch it) and bend the outer part of the wire w, ſo that it may be hung upon any thing as occaſion may require. This being done, hang it on the bar BB, and let nothing touch the outſide of the vial: then, electrify the bar for any time, ſuppoſe forty turns of the wheel; after which, ſtop

the

the wheel, and take the vial off from the bar, and ſet it on wax: or, which amounts to the ſame, let the vial be taken off from the bar very quick whilſt the wheel is turning, and immediately ſet upon wax as in the other caſe; and the filings, or water, will (to all appearance) be no more electrified than the bar itſelf. This is known from the various methods of determining the degree of electrification deſcribed in the firſt ſection, as

1. The exploſions from the wire w upon a perſon's approaching it for any number of times, will never exceed the exploſions from the bar B B, when approached in the ſame manner.

2. If the wire w be held for any time by a perſon ſtanding on wax (when the vial is taken off from the bar) he will be electrified in ſo ſmall a degree as ſcarce to be perceived. The ſame thing happens, nearly, if the bar be held in like manner by the perſon, the turning of the wheel being diſcontinued.

3. If the room be dark (which we ſuppoſe the caſe whilſt all the experiments are made that belong to this ſeventh propoſition) and the end of the wire w approached by a non-electric, a very faint light will appear to iſſue from it for a very ſhort time. The like effect will appear from the bar B B, provided one end thereof

thereof be as ſmall as the end of the wire, and ſhaped alſo like it.

LASTLY, If a non-electric body be brought near either to the wire, or the bar, all ſigns of their being electrified will preſently diſappear, and nearly in the ſame time.

EXPERIMENT XXV.

HANG the vial again upon the bar, and let a perſon ſtanding on the earth, take hold of the outſide of the vial, and electrify again by turning the wheel an equal number of times: then ſtop the wheel, and take the vial off, and ſet it on wax as before: or let the vial be taken off from the bar very quick (whilſt the wheel continues turning) and ſet upon wax; the filings within the vial will be electrified to a much greater degree than in the laſt experiment. But the bar will be electrified in no greater degree than it was in the firſt experiment. The difference between this, and the firſt experiment may be determined by any of the ſame methods. For example,

IF the firſt method be made choice of, there will iſſue a large number of exploſions from the wire w, and only two or three at moſt from the bar.

IF the ſecond be tried, not only one perſon, but ſeveral perſons will be electrified, and that in a very ſenſible degree: provided they all

ſtand on wax, and hold one another, and any one of them the wire w: which is far from being the caſe, if the bar in this experiment be held in like manner.

If the third method be made uſe of, a larger quantity of light will appear to iſſue from the wire w, and for a longer time than appears to iſſue in the firſt experiment; but the light from the bar in this, is the ſame with that in the firſt experiment.

And if the fourth method be tried, equal differences appear, for the bar will loſe all ſigns of being electrified in the ſame time (to all appearance) it did in the firſt experiment: but the vial will take up a much larger time before the filings and the wire w have loſt all ſigns of being electrified.

There are two other remarkable experiments that alſo prove the accumulation of electric matter to be greater in one caſe than in the other. They are performed with the ſame vial, but filled with water. The vial is to be without a cork; ſo that it may be electrified by a wire hanging upon the bar B B.

Experiment XXVI.

[a] If the vial be brought ſo near to the wire, by a perſon ſtanding on the earth, that the

[a] This Experiment was firſt made by Dr. *Bevis.*

end

end thereof touches the water in the vial, and the wheel be turned an equal number of times with the first or second experiment, and the vial afterwards taken away from the wire; on pouring only *part* of the water into a metal dish, which must be held by a person standing on wax; the person will be so strongly electrified, that if in his other hand he holds a metal spoon with a little warm spirit of wine, on the approach of a non-electric towards the spirit, it will immediately be seen to flame.

Experiment XXVII.

If the vial be filled again with water, and set upon wax, on electrifying it as in the first experiment, and ceasing to turn the wheel, the water will not be electrified to that degree it was in the third experiment, as may be readily found upon making the same trial; for the person will not be so much as sensibly electrified; even though the whole quantity of water be poured into the metal dish.

Hence it appears that the accumulation of electric matter is greater in the 25th and 26th experiments than in the 24th and 27th. Now if it shall appear that the resistance is less in the 25th and 26th than in the 24th and 27th experiments, we may conclude that in certain circumstances the accumulation of electric matter is reciprocally proportional to the resistance

fistance it meets with as it tends to expand and dissipate.

THAT the resistance given to the exit of the electric matter is greater in the 25th and 26th experiments than in the 24th and 27th, will appear from the following experiments and observations.

EXPERIMENT XXVIII.

IF the vial V be hung upon the bar BB (fig. 5.) and nothing touch the outside of the vial, electrify the bar again, and a light will be seen to issue from the end of the wire w after the first turn of the wheel, or rather before one turn is made; and light bodies will be moved towards the outside of the vial in like manner as towards the bar, but not at so great a distance as they are towards the bar. Continue the turning of the wheel, and these effects will not be greater nor will the electric matter be accumulated to a greater degree within the vial, than is mentioned in the 24th experiment.

OBSERV. VII. From this experiment it appears that the electric matter cannot be accumulated to a greater degree in the vial in these circumstances: and that less electric matter passes from the sides of the vial than from the bar. And therefore the resistance is greater from the vial than the bar.

EXPE-

Experiment XXIX.

If a perſon holds the point of the fine needle (or any other angular termination or edge of a non-electric body equally fine) towards the outſide of the vial V, and at the ſame diſtance from it with that in the fourth experiment from the bar, the filings in the vial will be electrified to a much greater degree than the bar, but weaker than that mentioned in the 25th experiment: after which, if the vial be not taken off, and the wheel be continued turning for any time, a light will be ſeen to iſſue from the wire w, in like manner as in the 28th experiment. But the filings will be electrified in no greater degree in ſuch circumſtances than is mentioned in this experiment.

Experiment XXX.

Move the point nearer, and the filings in the vial will be more ſtrongly electrified; and the light at the end of the wire w, will be ſomething longer, as to time, before it can be ſeen to iſſue.

Experiment XXXI.

Let the point of the needle be in contact with the vial, and the filings will be as ſtrongly electrified as in the 25th experiment, and the time alſo before the light can be ſeen to iſſue

from

from the wire w, will be as long as it was in that experiment.

Observ. VIII. From the xxixth xxxth and xxxist experiments, it appears that more electric matter passes into the vial than passes out from its sides in any instant: and that there are three different degrees of accumulation of electric matter in the filings, which are owing to the different degrees of resistance; the greatest accumulation being caused by the least resistance.

Experiment XXXII.

If instead of the point the thick end of the needle, or wire, be opposed towards the vial at the same distance with the ivth or xxixth experiment, the filings will only be electrified to an equal degree with the bar; or in other words, the bar and filings would be just as much and no more electrified, to all appearance, than if no such body had been opposed at that distance: so that the effects, with respect to the explosions from each, and the light from the wire w, are the same as those mentioned in the xxivth and xxvth experiments.

Experiment XXXIII.

Move the thick end considerably nearer the vial, and there will be a difference; for the effects now will be nearly the same with those mentioned in the xxixth experiment.

Experiment XXIX.

If a person holds the point of the fine needle (or any other angular termination or edge of a non-electric body equally fine) towards the outside of the vial V, and at the same distance from it with that in the fourth experiment from the bar, the filings in the vial will be electrified to a much greater degree than the bar, but weaker than that mentioned in the 25th experiment: after which, if the vial be not taken off, and the wheel be continued turning for any time, a light will be seen to issue from the wire w, in like manner as in the 28th experiment. But the filings will be electrified in no greater degree in such circumstances than is mentioned in this experiment.

Experiment XXX.

Move the point nearer, and the filings in the vial will be more strongly electrified; and the light at the end of the wire w, will be something longer, as to time, before it can be seen to issue.

Experiment XXXI.

Let the point of the needle be in contact with the vial, and the filings will be as strongly electrified as in the 25th experiment, and the time also before the light can be seen to issue from

from the wire w, will be as long as it was in that experiment.

OBSERV. VIII. From the xxix^th^ xxx^th^ and xxxi^st^ experiments, it appears that more electric matter paſſes into the vial than paſſes out from its ſides in any inſtant: and that there are three different degrees of accumulation of electric matter in the filings, which are owing to the different degrees of reſiſtance; the greateſt accumulation being cauſed by the leaſt reſiſtance.

EXPERIMENT XXXII.

IF inſtead of the point the thick end of the needle, or wire, be oppoſed towards the vial at the ſame diſtance with the iv^th^ or xxix^th^ experiment, the filings will only be electrified to an equal degree with the bar; or in other words, the bar and filings would be juſt as much and no more electrified, to all appearance, than if no ſuch body had been oppoſed at that diſtance: ſo that the effects, with reſpect to the exploſions from each, and the light from the wire w, are the ſame as thoſe mentioned in the xxiv^th^ and xxv^th^ experiments.

EXPERIMENT XXXIII.

MOVE the thick end conſiderably nearer the vial, and there will be a difference; for the effects now will be nearly the ſame with thoſe mentioned in the xxix^th^ experiment.

EXPERIMENT XXXIV.

If the thick end be in contact with the vial, there will be a greater difference: for the filings will be more strongly electrified, and to all appearance in the same degree with the xxv^th^ and xxxi^st^ experiments

Observ. IX. From the xxxii^d^ and xxxiii^d^ experiments it appears, that at equal distances with those mentioned in the xxix^th^ and xxx^th^ experiments there are different effects caused by the different degrees of resistance.

EXPERIMENT XXXV.

If, instead of the needle or wire, the rounded end of the poker, or the palm or back of the hand, be held towards the vial at the same distance with the fourth experiment, the filings will not be electrified more than the bar. And the light will appear at the end of the wire w,, about the same time it did in the xxviii^th^ experiment.

EXPERIMENT XXXVI.

Move the poker or hand half as near again, that is about nine inches, and there will be (to all appearance) no difference.

EXPERIMENT XXXVII.

But move it nearer, and there will; for the filings will be more strongly electrified than the bar: besides, there will be a small interval of

of time before the light appears at the end of the wire w.

EXPERIMENT XXXVIII.

On bringing the poker or hand in contact with the vial, the filings will appear to be electrified to as great degree as they were in the xxv^th^ xxxi^st^ and xxxiv^th^ experiments, and the light, before it is ſeen to iſſue from the wire w, will be much about the ſame time it was in thoſe experiments.

Observ. X. From the xxxvi^th^ and xxxvii^th^ experiments it appears, that at equal diſtances with thoſe mentioned in the xxix^th^ xxx^th^ and xxxii^d^ experiments, there are other degrees of reſiſtance cauſed, and different degrees of electric matter accumulated.

EXPERIMENT XXXIX.

If the perſon, inſtead of ſtanding on the earth, now ſtands on *wax*, as in experiment xiv. and oppoſes the point of the needle towards the vial at the ſame diſtance as was done in the iv^th^ and xxix^th^ experiments, the perſon will be electrified in a ſmall degree weaker than the bar; and the filings will be electrified in a ſmall degree greater than the bar: ſo that the accumulation of electric matter in the filings will be conſiderably leſs than the accumulation in experiment xxix. And if the vial in this experiment be not taken off, and the wheel

be continued turning for any time, a light will be seen to issue from the wire w, in like manner as in the xxviiith experiment, but not so soon as in that experiment, yet sooner than in the xxixth experiment.

Experiment XL.

Move the point considerably nearer, and the person will be more strongly electrified, so will the filings in the vial: and there will, after a shorter time than in the xxixth experiment or xxxth, issue a light from the end of the wire w. The degree of accumulation of electric matter in the filings in this experiment is less than the degree mentioned in experiment xxx.

Experiment XLI.

Move the point, so as to be in contact with the vial, and the electric matter will be accumulated in the filings to a much greater degree, but still less than in experiments xxv. or xxxi. In this case it will take up a longer time before the issuing of the light from the end of the wire w can be seen than it did in the last experiment; but lesser than is mentioned in experiments xxv. or xxxi.

Experiment XLII.

If the thick end of the needle or wire be opposed at the same distance from the vial as in the xxxixth and xlth experiments, the differences of electric matter accumulated will be

pro-

proportional; but less than in those two experiments. And if the wire be in contact with the vial, the accumulation will be the same as in experiment xli. The difference of time at which the stream of light begins to appear at the end of the wire w in each experiment will also be proportional.

EXPERIMENT XLIII.

IF the rounded head of the poker or the palm or back of the hand be opposed in like manner at the same distances from the vial as in the xxxixth and xlth experiments, the differences of electric matter accumulated in each experiment will likewise be proportional, but less than experiment xlii. excepting when the poker or hand are in contact with the vial, for then the accumulation appears to be the same with the experiments xl. and xli.

OBSERV. XI. From these last experiments it appears, that at equal distances with the xxixth, xxxth and xxxist experiments, lesser degrees of electric matter are accumulated by increasing the resistance, than were accumulated in the xxixth xxxth and xxxist experiments, where the resistance was less. It also appears, that the accumulation of electric matter is the same, whether a small or large surface de in contact with the outside of the vial.

EXPERIMENT XLIV.

If more persons stand also upon wax, and communicate with the person who holds the needle, wire, or poker towards the vial at the distances mentioned in the preceding experiments, the filings will be more strongly electrified at those respective distances, than they were in these experiments; and still more so to a limited degree, as the persons added are more in number. And in each experiment it will be a longer time before the light appears at the wire w.

EXPERIMENT XLV.

The like difference in proportion will happen when the thick end of the needle or wire is opposed (the same persons continuing on wax) at the like different distances.

EXPERIMENT XLVI.

The same will happen in proportion when the rounded head of the poker is opposed (the same person continuing on wax) at the like different distances also.

Observ. XII. From these experiments it appears, that the accumulation is made greater by making the resistance less than it was in experiment xli. And since upon the whole by opposing either fine points, blunted points, or surfaces of non-electric bodies at different distances towards electrified bodies, very different

ferent effects are produced, the air between the electric body and the body opposed seems to be one cause, which helps to resist the exit of the electric matter, and occasion these differences.

EXPERIMENT XLVII.

If the needle or any other small quantity of non-electric matter pointed, have either of its ends *stuck* into wax, and afterwards brought in contact with the vial whilst it is electrifying, the filings in the vial (to all appearance) will be no more electrified than in experiment xxiv.

OBSERV. XIII. From this experiment it appears that the resistance is made very little less than in experiment xxiv, as there is not a quantity of non-electric matter to pass from the vial, and expand itself in.

EXPERIMENT XLVIII.

If the same pointed body be stuck upon a very thin piece of wax, the opposite part of the wax to the fixed point, being in contact with the earth, and the other point at the same time brought in contact with the vial, the filings in the vial will be more strongly electrified than in experiment xlvii.

OBSERV. XIV. For the resistance to the passage of the electric matter from the vial into

the earth is made leſs by the interpoſition of thin wax.

EXPERIMENT XLIX.

If inſtead of a thick quantity of wax, which we before ſuppoſed the perſon to ſtand on, we make uſe of a quantity that is very thin, as in the laſt experiment, the effects in all reſpects will be very different from what are mentioned in thoſe experiments where the thick wax is made uſe of: for the perſon will not be ſo ſtrongly electrified, the other circumſtances being the ſame; though a greater quantity of electric matter will paſs from the vial. It will be longer alſo before the light at the wire w appears, as well as before light bodies are moved too and from the bar, at the greateſt diſtance. The accumulation of the electric matter in the filings in thoſe circumſtances will alſo be greater at equal diſtances, but leſs than the accumulation in experiment xxv.

OBSERV. XV. From hence it appears, that the reſiſtance is farther varied and made leſs by the thin wax: and yet the reſiſtance is greater, than when no wax is interpoſed: therefore there muſt be ſtill different degrees of accumulation of the electric matter.

EXPE-

EXPERIMENT L.

If any of the non-electric bodies mentioned in the xli[st] xlii[d] and xliii[d] experiments, are placed in contact with the vial and the earth at the same time, a light body placed at a small distance from the bar, upon the earth, will not be moved towards the bar at the first, second, third, or fourth turn of the wheel. But when the light issues from the wire w, then (or a very small interval of time before) the light body will be readily moved to and from the bar very quick.

EXPERIMENT LI.

If nothing touches, or is near the outside of the vial, the same light body placed at the same distance from the bar upon the earth will, on the first turn of the wheel, be moved to and from the bar very quick.

Observ. XVI. From these last experiments it appears, that the electric matter coming from the machine into the bar, does not pass so readily from the sides of the bar, as into the filings, until the electric matter is accumulated in the filings to its greatest degree.

EXPERIMENT LII.

If the glass vial be very thick, then those experiments will not succeed; for a very little only of the electric matter will be found to

pass

pass through the glass, therefore the effects are very different.

Observ. XVII. From this experiment it appears that the resistance may be made too great.

Experiment LIII.

If the glass vial be exceedingly thin, those experiments will not succeed in the manner we have mentioned neither; for the electric matter will be found to pass more readily thro' the thin glass than thro' a thicker glass, as we have shewn by experiment iii. sect. ii. and observ. xiii. and xiv.

Observ. XVIII. From this experiment it appears, that the resistance may be made too *little*.

The same thing is manifest from points, and the surface of the bar in observation i. where it appears that the electric matter passes away the quickest, where the resistance given to its exit is least.

Corollary.

From the whole it follows, that in order to produce the greatest accumulation of electric matter, it is necessary there should be a certain degree of resistance; and that the resistance should be equal and uniform. For it has been found, that if the glass be of an unequal thickness, or have a flaw, hole, or crack in it, the

the electric matter will eſcape more readily through thoſe parts, than through any other part of the glaſs.

That this uniform and equal reſiſtance alone is neceſſary for producing the greateſt accumulation will be farther confirmed from the two following experiments.

Experiment LIV.

If the vial be covered on the outſide with a non-electric, if points and edges are avoided, on electrifying the outſide thereof only, the ſame effects to all appearance will inſue. This will be determined by a very eaſy method in propoſition xi.

Experiment LV.

[a] If a plane of glaſs G (fig. 6.) of the ſame thickneſs with the vial, be covered cloſe on each ſide with a non-electric, ſuppoſe leaf gold, ſilver, braſs, or thin lead t, leaving an inch and an half or two inches uncovered all round the glaſs on each ſide next its edges e e e, on electrifying either ſide, ſuppoſe t, whilſt the contrary ſide is in contact with the earth by means of the non-electric n, the electric matter will be accumulated to as great a degree on the electrified ſide t, as it was in experiment xxv.

[a] This experiment was made by Mr. *Smeaton.*

Upon

Upon the whole, from the preceding experiments, we gather the following general truths, with regard to different bodies resisting the passage of the electric matter with different degrees of strength.

1. That glass, wax, and other electric bodies resist or obstruct the passage of the electric matter more than air: provided that the electric bodies are not very *thin*.

2. That one inch of air seems to resist less than one foot of air; and one foot less than three feet; and so on.

3. That air in general resists more than the surfaces of non-electric bodies.

4. That the surfaces of non-electric bodies resist the passage of the electric matter more than the obtuse ends, blunt edges, or obtuse angular terminations of the same kind of bodies.

5. That obtuse ends and blunted edges or obtuse angular terminations of the same kind of bodies, resist the passage of the electric matter more than fine points, sharp edges, or acute angular terminations of the same kind of bodies.

6. That the finest points, edges, and angular terminations of non-electric bodies, resist the passage of the electric matter *least* of all.

When

When we hereafter ſpeak of the reſiſtance, or obſtruction of glaſs, wax, air, non-electric ſurfaces, obtuſe non-electrics, or acute or fine points, or edges of non-electric bodies, we would be underſtood to mean that power or reſiſtance, whatever may be its cauſe, which prevents the paſſage of the electric matter more, or leſs, as the bodies made uſe of differ in ſhape and kind.

It may ſeem difficult to conceive, how different degrees of accumulated electric matter in the ſame body are cauſed, by varying the reſiſtance the fluid meets with in its tendency to diſſipate, as was ſhewn in the proof to the laſt propoſition, ſince it appears that the leaſt accumulation is cauſed when the reſiſtance it meets with is increaſed, and the greateſt accumulation when the reſiſtance is decreaſed.

Now ſome perhaps may think that theſe ſurpriſing effects are owing to an attractive power of the earth, acting variouſly in different circumſtances, and that the accumulation is proportional to the attractive power.

But were this ſuppoſition true, pointed bodies oppoſed to the vial at ſome diſtance, in the manner we have treated of, ought to produce the leaſt accumulation of electric matter in the vial when compared with ſurfaces oppoſed at the ſame diſtance and in the ſame cir-

cumstances; whereas by experiment it is found they produce the greatest: and when any pointed body is in contact with the vial, the effects are the same with respect to the accumulation as when a surface is in contact with the vial, and in the same circumstances: therefore those effects must arise not from an attractive power, but from the resistance the fluid meets with in tending to dissipate and expand itself.

We have shewn how to accumulate electric matter in the vial; we will now shew how the original quantity of electric matter in the same vial may be lessened or attenuated.

EXPERIMENT.

Set the machine on wax, and let a person standing on the earth take hold of the outside of the vial, and instead of hanging it upon the bar BB, by the wire w, let that wire touch any part of the frame of the machine, or the person turning the wheel, who also must be on wax. Let a wire, or any non-electric body communicate with the bar BB and the earth, after forty or fifty turns of the wheel, take the vial away, but, whilst it continues turning, and afterwards, set it upon wax. And the original quantity of electric matter in the filings within the vial, will appear to be attenuated to such a degree, as to produce effects equally

strong with those mentioned in experiment xxv. where the electric matter was accumulated.

All the effects we yet know of, arising from this attenuation, are the same with those produceable from the accumulation; excepting that remarkable difference of the acceding and receding of light bodies particularly related in the experiments following proposition iv. which hold equally true in this case.

PROPOSITION VIII.

The electric matter, when accumulated, seems to be dissipated, on causing an explosion, not only through the part where the explosion is made, but through the whole surface of the body, even though an electric body be interposed, provided it be thin.

Experiment I.

* Let a thin plate of glass ten, fifteen, or twenty inches square be gilt with leaf gold on each side (or covered with sheet lead) within two inches of the border; or rather, let the thin glass vial *V* (that being most commonly used) which is filled with filings of iron, be covered close on the outside with sheet lead, leaving about two inches and a half uncovered at the

* This experiment was made by Mr. *Canton* Master of an Academy in *Spittle Square, London.*

the neck. Electrify the matter within, by means of the wire w passing through the neck of the vial, whilst the outside covering is held by a person standing on the earth. When it is electrified, set the vial upon any electric body R; this done, approach the wire w with your finger, and there will be an explosion; upon repeating it, a second, and a third will ensue, and so on. The like will happen on approaching the external leaden covering; when you have touched that so often till the explosions cease, approach the wire w again and an explosion will again ensue; after this, you will have another from the outward covering; and so alternately from each, until the whole accumulated matter is nearly dissipated.

Experiment II.

If the non-electric covering on the outside of the vial be but half an inch, or an inch in extent, these effects will be less from the covering than in the other case where the covering is larger.

Experiment III.

If the glass be very thick, these effects are not produced.

These phænomena seem to be owing to the force of the explosion; for as the explosion seems to be made only when the electric matter is sufficiently condensed, or collected into a kind

kind of focus, and as action and re-action are equal, the particles next in succession to those in the focus may be supposed to be checked or repelled, and those to check or repel one another with equal force. By which means those particles lying nearest the surface of the glass within the vial, may be forced through the thin glass into the non-electric body on the outside. And consequently if a non-electric cover the greatest part of the surface of the glass, and the glass itself be of an *even thickness*, the particles must be forced *equally* into the non-electric from all parts alike. Now supposing this the case, the greater the explosion is, the greater must be the check, or repelling force; and consequently the more the electric matter forced through the glass into the surrounding covering.

And again, the greater or less the non-electric covering on the glass is, the greater or less also must be the quantity of electric matter forced through the glass into the covering. All this we find to be true in fact.

Corollary I.

If this reasoning be true with respect to the effects produced by the explosion where a thin electric is interposed, it should hold equally true where the electric body is not interposed, as in that case the resistance is less. And there-

fore we ſuppoſe that when the bar is electrified, and an exploſion cauſed, all the electric matter that does paſs off from the bar at that inſtant, does not paſs out at the point, or part where the exploſion is made, though the moſt conſiderable part may eſcape there, but from every part of the ſurface; provided the reſiſtance in all the parts of the ſurface be equal.

This equality of reſiſtance may be had the neareſt by making uſe of any poliſhed metalline body which is ſpherical.

The accumulation of electric matter in the vial, bar, or ſphere, is not totally diſſipated by repeated exploſions, as appears from the following experiment.

Experiment.

Fix a fine downy feather upon the wire of the vial, bar, or ſphere; when they are electrified, approach them with a non-electric till the exploſion ceaſe: after which approach the feather and ſome of the fibres will move towards the non-electric and continue to do ſo upon the repeated approaches for ſeveral times.

When one part of a non-electric body, or bodies but in contact with one another, ſuppoſe D, touches one ſide of an electric V, which has oppoſite on its other ſide a non-electric C in contact with it, and another part of the ſame body D is brought near the laſt mentioned non-

non-electric C: the body D so disposed, together with the electric V, and the opposite non-electric C, we call the * *circuit*, and in such circumstances we say the circuit is completed. And the non-electric D, completing the same, we call the *dissipator*.

The electric V is represented by the vial V, (fig. 7.) The dissipator D, by the crooked bar of iron, wire, or chain, D. And the non-electric C, by the filings within the vial V and its wire w.

PROPOSITION IX.

When electric matter is accumulated in the filings to the greatest degree, the loudness of the explosion and quantity of electric matter dissipated on completing the circuit, seem in some measure proportional to the points of non-electric contact with the *out* and *in* side of the vial.

PROOF BY EXPERIMENTS.

Experiment I.

When the filings in the vial are electrified to the greatest degree, let the dissipator have that end very small which is to be in contact with the vial; on completing the circuit, there will be an explosion, but not a large one. If

* The experiment of the electrical shock produced by means of a glass vial, was discovered in *Holland*, and first made known to the world by Professor *Muschenbroeck*. But the nature of the electrical circuit was first explained by Mr. *Watson*.

the circuit be completed a ſecond or a third time, the ſecond exploſion to appearance will be the ſame with the firſt, and the third will be rather weaker, and ſo on, till nearly the whole accumulated electric matter is diſſipated.

EXPERIMENT II.

IF the diſſipator have that end much broader which is to be in contact with the vial (ſuppoſe two or three inches) the firſt exploſion will be larger, and the ſecond and third much leſs.

EXPERIMENT III.

IF the diſſipator have that end next the vial ſo broad as to be in contact with the vial in every part for the compaſs of ſix or ſeven inches ſquare, the firſt exploſion will be much greater than the firſt, and the ſecond much leſs than the ſecond in the laſt experiment.

EXPERIMENT IV.

INSTEAD of filling the vial with filings, let there be only a very ſmall quantity thereof in the vial, or let the inſide non-electric contact with the vial be no greater than in the firſt experiment, and afterwards that non-electric electrified; on completing the circuit with the ſame point of the diſſipator oppoſed to it, there will be no viſible exploſion.

EXPERIMENT V.

INCREASE the contact in the vial, ſo that it may equal the contact on the outſide thereof men-

tioned in the ſecond experiment: on electrify-ing the inſide and completing the circuit with the ſame point of the diſſipator on the outſide, an exploſion will be produced, but leſs than that in the firſt experiment.

Experiment VI.

If the contact on the outſide be increaſed ſo that it may equal the contact in the inſide mentioned in the firſt, ſecond, and third experiments; and the inſide contact be no greater than the outſide in the firſt experiment; the effects will be the ſame with thoſe mentioned in that experiment.

Experiment VII.

If the inſide and outſide contact are alike, and equal to the outſide contact in the ſecond experiment; the effects will be leſs than thoſe mentioned in the ſecond experiment, but greater than in the firſt experiment.

If the inſide contact be equal to the outſide contact in the ſecond experiment, and the outſide the ſame with the ſecond experiment; the effect will be the ſame with thoſe mentioned in that experiment.

From theſe experiments it appears, that the greater the ſurface of a non-electric body is which touches the outſide of the vial when filled with filings, the greater the exploſion and diſſipation. And that the leſs the ſurface is, the

less are those effects: but the greater the surface of the non-electric, the greater the quantity of contact, and *vice versa*. Therefore the proposition is true.

This is farther confirmed by proposition viii. with its proof and experiment lv. proposition vii.

SECTION VI.

We have shewn what effects arise from a non-electric body when it is in contact with the outside of the vial. We will now cover the outside of the vial with a non-electric properly, by which means it will be better fitted for more extraordinary experiments, and the vial, when covered, may be said to be properly prepared.

To do this, take the same vial made use of before, or let a quart or larger vial *V* of the thinnest kind, and as *equally* so as can be had (the longest kind are the properest) be almost filled with clean filings of iron, quicksilver, granulated lead, or water: if it be with filings of iron, take care that they are shaked together very well, so that they may lie close to the sides of the glass: then put a cork into the neck of

of it, and force the wire w through the cork into the filings. The wire w ſhould be very thick, and the outer end rounded off. After this, wax all the cork which is without the vial. Now take a clean thin piece of milled, or ſheet lead (ſuch as comes from *India* in which tea is brought) as much as will wrap twice round the vial, and cover the ſurface of the vial from the bottom to within two inches and an half of the cork. Roll this piece which we call the *covering*, very tight round the vial, and afterwards bind it very well with one continued piece of wire, well nealed; and where you diſcontinue the binding, make a loop X for a bar, chain, or wire D, to be hooked on, as occaſion may require.

Now any part of this covering, or the loop X, may be touched with the diſſipator (when the circuit is to be completed) for the effect will be the ſame[a].

N.B. If the vial could be covered over with quickſilver in the manner looking-glaſſes are, or with any other non-electric body without points or edges, it would be preferable to the leaden covering and its binding wire.

[a] This method of covering the vial with *lead* was diſcovered by Dr. *Bevis*, which is indeed preferable to mine with water, which I at firſt made uſe of, as it is more convenient to manage.

PROPOSITION X.

WHEN the electric matter is accumulated in the vial to the greatest degree, the greatest effects are produced by completing the circuit.

EXPERIMENT.

Let the filings in the coated vial be electrified to the greatest degree possible under such circumstances (see experiment xxv. section v.) then if a person with one hand touch the covering of the vial, and with the other approach the wire w at the same time, he will receive a much more painful shock, than if he approached the wire w only (here we suppose the vial to continue hanging upon the bar or set upon wax.) If horses, oxen, sheep, dogs, or any other animals be the dissipator or part of it, they appear to be affected in like manner. The explosion also will be much greater, and the accumulated matter will be in a manner totally dissipated.

THE explosion will be still something greater, and the accumulated electric matter will be also in a manner totally dissipated, if a single piece of iron be the dissipator instead of the person.

IT has been already shewn (by proposition viii.) that when the vial is electrified and placed upon an electric body, the approaching of

of the wire w only will not discharge the whole of the accumulated electric matter: nor indeed will it make any apparent difference, as some perhaps might imagine, if the covering be touched and the wire w approached at the same time, but with separate bars of iron equal in weight to the quantity of non-electric matter contained in the vial; not even supposing the bars or other non-electric matter to be increased to any quantity whatsoever. But when the external covering is touched at the same instant of time that the wire w is approached, either by two different bodies of the same kind, but in contact with each other, or by one only, and that either large or small, which we have called the dissipator, the case is then widely different, for the electric matter is in a manner totally lost and dissipated.

How this is effected is not easy to say, nor shall we take upon us absolutely to determine, being as yet not thoroughly satisfied from experiments. However, in order to assist those who may pursue these inquiries farther, we shall set down several experiments of different kinds, and from them propose a query how the completing the circuit seems to cause so sudden and great an explosion and dissipation of the electric matter.

EXPE-

EXPERIMENT I.

WHEN the filings in the vial are electrified to the greatest degree (which in each of the following experiments we shall always suppose to be the case) set the vial upon a cake of wax, and let nothing touch either the vial or the wire w, and it will be a considerable time before the electric matter will be dissipated.

EXPERIMENT II.

LET the vial stand on the earth and there will be (to all appearance) but a very little difference; the electric matter taking up rather a less time before it is dissipated, than in the first experiment.

EXPERIMENT III.

SUPPOSE the vial for this one experiment to have any part of the bottom or sides ground *extremely thin*, and to be electrified to an equal degree with the foregoing experiments; in order to do this, let some sealing-wax be put upon the thin place whilst it is electrifying, and after the vial is electrified, take the sealing-wax away, and set the vial on the earth; so that a non-electric may touch the thinnest part of the glass and the earth at the same time. The accumulated electric matter in these circumstances, will be dissipated nearly in half the time it will in the first or second experiment.

Experiment IV.

When the filings within the vial V are electrified and set on any electric R, if a person standing on the earth, touch with his hand, or hold the wire w that passes into the vial, for some time, he will cause the whole of the accumulated matter within the vial to be dissipated in a shorter time than in the first or second experiment.

Experiment V.

Let a fine feather, whose fibres are long and slender, be fixed upon the bar B B, and let the bar be electrified; when it is, cease to turn the wheel, and the fibres of the feather will move towards a non-electric when approached near it, though a person standing upon the earth continues to hold the bar in his hand for some time. This experiment is similar to the last experiment, and as such we have introduced it here.

Experiment VI.

Again, instead of touching the wire w with his hand, as in the fourth experiment, let him hold the point of a needle in contact with the wire after the vial is electrified, and set upon wax, in this case the whole of the electric matter will be dissipated in a very short time compared with the first, second, third, or fourth experiment last mentioned.

Expe-

EXPERIMENT VII.

IF the ſixth experiment is repeated with the ſame circumſtances, except that the perſon now ſtands upon an electric R, he will be electrified in a ſmall degree, and the whole of the accumulated matter in the vial will not be diſſipated in ſo ſhort a time as in the ſixth experiment.

EXPERIMENT VIII.

WHEN the vial is electrified, ſet it upon the earth, and let a perſon ſtanding upon wax touch the wire w, the accumulated electric matter will not be diſſipated as ſoon to appearance as is mentioned in the ſixth experiment.

EXPERIMENT IX.

ELECTRIFY the vial again, and let the perſon ſtanding on wax now take hold of the covering of the vial inſtead of the wire w, at the ſame time let the wire w touch the earth; and there will be a conſiderable difference; for the accumulated electric matter will now appear to be diſſipated ſooner than is mentioned either in the firſt, ſecond, or eighth experiments, and very near in the ſame time with the fourth experiment.

EXPERIMENT X.

LET the covering of the vial V be brought within an inch and an half or thereabouts of the top of the neck, and let the outward extre-

mity of the wire w be covered with dry wax: ſoon after the vial is filled with electric matter, a light appears to iſſue from the wire at the neck, which light tends towards the covering, and in a little time explodes, provided the wheel be continued turning. After this a ſecond effect equal to the firſt cannot be produced without electrifying again. Nor is there any ſign of electric matter being left within the covering.

EXPERIMENT XI.

AGAIN let there be faſtened to the covering of the vial V, a wire or chain C, one, two, three, or more feet long: and let the vial be electrified to its greateſt degree, and then placed upon wax. If the wire or chain be taken hold of, even with an electric R, and brought by means thereof to the wire w, ſo as to complete the circuit, a large exploſion will enſue, and almoſt the whole accumulated matter will be diſſipated. If inſtead of holding the wire or chain in the manner abovementioned, either of them be dropped upon the wire w, the effects, to all appearance, will in every reſpect be the ſame. In both theſe caſes, after the large exploſion, a ſmall one, or two, may be produced by repeating the circuit, after which no electric matter will be found in the wire or chain C upon a perſon's touching of them.

EXPE-

Experiment XII.

[a] If the diſſipator D be a bar, wire, or chain, and there be a piece of gilt leather, about the ſize of a crown, with its edges waxed round, fixed in the middle, either to the approaching part of the diſſipator, or the part of the wire w approached, on electrifying the filings in the vial, and completing the circuit in the middle (or thereabouts) of the leather, a viſible hole will be made through the leather (a ſtrong proof that the electric matter paſſes through bodies) and a loud exploſion will enſue.

Experiment XIII.

If the end of the diſſipator D, next the covering of the vial, or the covering it ſelf, have alſo a piece of gilt leather fixed to it at the ſame time that the other piece is on the other end of D, or the wire w, the filings being electrified, on completing the circuit in the middle or thereabouts, of each piece of leather, a hole will be made through each, and to all appearance in the ſame inſtant. In theſe experiments where the circuit is completed, the ſame effects to appearance are produced, whether the diſſipator touches the wire w or the covering firſt.

The following account is a deſcription of

[a] Dr. *Bevis* obſerved this effect; the experiment he made was much the ſame with this.

an apparatus like that of the vial with its circuit to condenſe air in. It is ſo contrived that the effects ariſing from condenſed air may be compared with thoſe ariſing from the accumulated or condenſed electric matter in the electrified vial.

Let V (fig. 9.) repreſent a veſſel of glaſs; W a hollow pipe exhauſted of air fitted cloſe to the neck of the veſſel V, ſo that no air can eſcape: one end of which opens into the veſſel, the other end has a ſtop-cock at n. Let D D repreſent another hollow pipe communicating with V at z; and with W at y, like the diſſipator: at which places there are alſo ſtop-cocks. And let there be alſo another ſtop-cock at x.

Case I.

Suppose now theſe ſtop-cocks x y and z turned, or ſhut, ſo that no air can paſs from V into the pipe D D, or through x into the air without. Condenſe four atmoſpheres of air into the veſſel V through the ſtop-cock n: then turn the cock n till the aperture in it is almoſt cloſed, and only a very little air eſcapes through it. If the time from its firſt beginning to iſſue to the time it ceaſes to iſſue be now examined, it will be found to be very conſiderable. See the firſt experiment, propoſition i.

Case

Case II.

Suppose every thing as before, but instead of letting the condensed air escape through n into the open air without, let it escape through the same aperture into an exhausted receiver, which held, before it was exhausted, more air than is condensed in V. And it will take up a shorter time to escape or expand itself in to the same degree, than it did in the first case. See the fourth and fifth experiments, proposition x.

Case III.

Condense the same number of atmospheres into the vessel again, and turn the cock n as before, leaving, as near as can be judged, the same, or an equal passage for the condensed air to escape into the open air: immediately after this, suppose the stop-cock x to be turned, leaving also a passage for the air to escape through it as it did from n, but somewhat larger. The rushing out of the air then through each passage will not be equal, but rather greater from x than n: therefore the condensed atmospheres will escape, or pass out through these two passages or apertures in x, and n, nearly in half the time they did from a mean between the first and second cases. See the third experiment, proposition x.

CASE IV.

SUPPOSE now the paſſage for the air to eſcape, at n (the veſſel being again equally filled with air) to be a little larger than the paſſage for the air to eſcape at x, the aperture at x continuing the ſame as in the laſt caſe, then the greateſt quantity of air will eſcape from n: and the time it will take up before the condenſed air has eſcaped through both, will be ſhorter than in the laſt caſe. See the ſixth and ninth experiments, propoſition x.

CASE V.

TURN the cock x ſo that no air can eſcape by it, and condenſe the air again to an equal degree as before, leaving the aperture n as ſmall as is mentioned in the firſt caſe: immediately after this, ſuppoſe y and z to be turned at the ſame inſtant of time, that the air may eſcape into the pipe DD; in this caſe it is eaſy to conceive that there will ruſh out a greater quantity of air in a ſhorter time than in the fourth caſe. See the xth, xith, xiith and xiiith experiments, propoſition x.

IT is manifeſt too, that as the air in the pipe grows denſer and denſer as more ruſhes into it at each end, the entrance of the air will be ſlower and ſlower; as it will be every inſtant more and more obſtructed by reaſon of the denſity encreaſing every inſtant, till it becomes

of an equal denſity with that in the veſſel, and then no more can enter the pipe.

Now if the air could be diſcharged the inſtant it attempts to enter the ends of the pipe, it would, by its extreme quick motion, cauſe a ſingle report.

QUERY II. Do not the phænomena produceable from the vial, when the matter within it is electrified, ſquare with theſe experiments relating to air? For as we ſaid before, they appear to be ſimilar as to their elaſticity, and ſo far they ought to be governed by the ſame laws: which indeed ſeems to be the caſe, as thus:

THE vial V filled with air, and the vial V filled with electric matter, are veſſels of the ſame kind; the obſtructions, or different reſiſtances to its paſſing out of the vial, are the ſtop-cocks n, x, y, z: for example, n repreſents the obſtruction ariſing from the wire w; x the obſtruction of the glaſs; y and z are the obſtructions at each end of the body D completing the circuit: and the hollow pipe D D is the diſſipator D, which completes the circuit.

THE firſt caſe, where all the ſtop-cocks are ſhut, except that at n, is ſimilar to the electrified vial placed as in the firſt experiment; for in that experiment the reſiſtance at the wire w may

may be considered as similar to the stop-cock at n.

The second case, where the exhausted receiver is fixed to n, is somewhat analogous to the fourth and sixth experiments: for in these experiments the resistance was made less by the non-electric contact, and here it is greatly lessened by taking away the air.

The third case, in which the stop-cocks n and x are near equally opened, is similar to the third experiment, where the resistance given to the passage of the electric matter is lessened by a non-electric touching the thinnest part of the glass.

The fourth case, where the stop-cock n is more opened than x, is somewhat similar to the sixth and ninth experiments, in which the electric matter is found to dissipate faster where the resistance is least.

The last case may serve to illustrate the xth, xith, xiith, and xiiith experiments. For by proposition viii. the electric matter, on causing an explosion, is found to pass both by the wire w and the covering. And by the xiith and xiiith experiments, it is found that the explosion, and quantity of electric matter dissipated by that explosion, is greater when the circuit is completed, than when it is not completed: And it is further found that after an explosion, when

the circuit is completed, there is no ſign of any electric matter within the diſſipator.

Query III. Do not theſe things ſhew that the electric matter is diſſipated the quickeſt by this method of completing the circuit? And may not the large exploſion which attends this experiment, be the reſult of ſeveral ſmall exploſions ſucceeding one another ſo quick as to appear but one?

Query IV. Now as action and re-action are always equal, muſt not the original quantity of electric matter within the diſſipator be acted upon immediately after the exploſion, in like manner as is ſhewn in the eighth propoſition, ſo as to produce the ſame effects as if the accumulated electric matter had actually paſſed through the diſſipator?

For two contrary (violent and ſudden) motions, together with the reſtrictive power of the particles themſelves, may be ſufficient to cauſe that ſtrange and painful ſhock or convulſion of the nerves and muſcles, which is generally felt by animals, when they are ſo placed as to make up part of the circuit.

All the circuit experiments, and the experiment following propoſition viii. ſeem to ſhew that this convulſive ſhock is proportional to the magnitude of the exploſion. For the greateſt ſhock is always produced when the

explo-

explosion is greatest; and the least shock when the explosion is least. By parity of reasoning it follows, that there should be no shock where there is no explosion at the times of completing the circuit: and that it is the case, will appear from the following experiment.

EXPERIMENT XIV.

WHEN the filings in the vial are electrified to their greatest degree, let a person standing on wax, take hold of the covering of the vial with one hand, whilst in the other he holds a non-electric body, finely pointed, suppose a needle, with the point towards, and within two and a half or three inches of the wire w. By this means there will no explosion, nor any convulsive shock felt by the person holding it, yet in a very short time the greatest part of the electric matter will appear to be dissipated and lost.

OF the same nature with this last is the following experiment.

EXPERIMENT XV.

WHEN the filings are electrified, set the vial on wax, and fix the middle of the wire, which in this experiment is to be the dissipator, in a stick of sealing-wax, lest any one should imagine the electric matter passes into the person by this wire: then bring the ends of the wire equally near the covering of the vial and the

wire w at the ſame time, ſuppoſe within an inch and a half of each. And if the room be darkened, a ſtream of light will be ſeen at the ends of the wire as long as any conſiderable quantity of electric matter remains within the vial. After this the wire that completes the circuit will not give the leaſt ſign of any electric matter being accumulated within it.

Let it be obſerved, that we cannot conclude from the diverging of the electric matter, which body it iſſues from: becauſe the electric matter, both in paſſing out of a body and paſſing into it, has the ſame appearance.

This is manifeſt not only from reaſon but experiment.

Experiment XVI.

For, if a perſon ſtanding on the earth holds a pointed body near the bar, whilſt the wheel is turning, a light will appear to iſſue and diverge from the point.

Experiment XVII.

Let the ſame perſon now ſtand on wax, and take hold of the bar, and hold the point from the bar, and the ſame appearance of light (ſuch as the divergency) will be at the point.

In the firſt caſe, the electric matter paſſed into the perſon at the point, and in the laſt caſe, the electric matter paſſed out of the perſon at the point.

To

To ſhew this otherwiſe, let the perſon ſtanding on wax with his arms extended from one another, hold in each hand a needle, and let one of the needles be within a few inches of, and point towards the bar, whilſt the other needle points from the bar. If the bar be electrified, a light will appear at the point of each needle, and ſeem to diverge from each point at the ſame time.

The next experiment ſeems to illuſtrate all the reaſoning we have advanced in the proof of this laſt propoſition.

Experiment.

[a] Set the vial, after the filings are electrified upon a cake of wax, and let a ſmall ball of metal, paſte, clay, or cork, not too heavy, be ſuſpended at the end of a thread (moiſtened with water) hanging from the top of the room in ſuch manner, as that the ball, when in a ſtate of reſt, may be within a few inches of the leaden covering of the vial. Upon a perſon's touching the wire w in the neck of the vial (he ſtanding on the floor) a ſmall exploſion will enſue, and the ball will have moved from its perpendicular, or natural point of reſt,

[a] An experiment of the ſame kind with this was made by Dr. *Le Monnier* at *Paris*, and communicated along with ſome others to the Royal Society in *London*, by Mr. *Needham*.

towards the covering of the vial, where it will continue as long as the person continues to touch the wire (without being repelled) and whilst any considerable quantity of electric matter remains within the vial.

PROPOSITION XI.

If a person completes the circuit by taking hold of the covering of the electrified vial with one hand, and by approaching the wire in the neck of it with the other, the greatest painful shock will be always felt in those parts which lie in the shortest line that can be drawn through the person making up the circuit from the outside covering to the wire. And this is universal, supposing the person an uniform non-electric.

In the case abovementioned, the greatest shock will be given along the arms and across the breast; if a leg and an arm complete the circuit, whether they be on the same, or on different sides, the greatest shock will be given in those parts which lie in the shortest line of communication between the leg and the arm [a].

N.B. The filings must not be electrified to the greatest degree, lest the person who makes

[a] This method of affecting any part of the body without affecting the other parts, I discovered in the year 1746.

the

the experiment, ſhould receive any hurt from the violent effects of the electric matter.

THE ſafe method of trying this experiment, is to make uſe of the vial mentioned in thoſe experiments following the ninth propoſition. And inſtead of covering the outſide of the vial with lead, and completing the circuit with a wire, let the perſon take hold of the uncovered vial, and graſp it cloſe with one hand, whilſt with the other he approaches the wire w; and the effect will be much leſs. And it will be ſtill leſs if the perſon only touches the vial with his finger inſtead of graſping it with his hand by propoſition ix.

PROPOSITION XII.

NON-electric bodies placed without the circuit, will, on completing the circuit, be affected in the ſame manner (but in a leſs degree) as if part of the accumulated electric matter had paſſed into them.

EXPERIMENT I.

ELECTRIFY the filings in the vial V (fig. 10.) and place the vial in a darkened room upon the wax R, on which lay likewiſe in any direction ſeveral pieces of iron c, d, e, f, g, in ſuch a manner, that the firſt piece c may touch the outſide covering of the vial V, and that the reſt

rest may not be distant from each other above $\frac{1}{10}$ of an inch. Approach the wire w which is in V with one end of the iron rod r, the other end resting upon c, and you will have an explosion, not only from the iron rod, but from the several pieces of iron c, d, e, f, g.

EXPERIMENT II.

THE same effect is observed when a piece of gilt leather S Y is made use of in the following manner. Let the end thereof S (fig. 11.) be in contact with the covering of the vial V, and when the filings are electrified, upon bringing the part t or x of the leather towards the wire w by means of an electric, an explosion will ensue, and at the same time nearly a light or small explosion will be perceived in the little intervals of the broken leaf-silver which lie between t Y, or x Y, without the circuit, as well as in the intervals which lie between S t or S x within the circuit. And those little explosions will be more in number, and also more visible, if a person takes hold of the leather at Y or x, and still more so, the nearer the person's hand is to t or x.

SECTION VII.

PROPOSITION XIII.

AN explosion never happens but when the issuing electric matter is very much condensed.

THIS appears from pointed metal bodies when electrified in dark places. For the electric matter, in passing from a pointed piece of metal, will be seen to issue from it in diverging rays; on bringing a non-electric body near it, that divergency lessens; and in proportion as the body comes nearer, the divergency grows less and less; till at length the rays continuing to close, and to recede more and more from their divergency, till they are brought to a kind of focus, an explosion is made.

FROM the electric matter first approaching towards a parallelism, and afterwards converging to a kind of focus before the explosion is made, the condensation must be greatest at the time of the explosion.

IF the acute end of this piece of metal be an exceeding fine point, no sensible explosion will insue, even though it be approached exceeding near by the non-electric: because the electric mat-

matter will now appear to paſs out nearly in a parallel direction, and more equally and faſt, forming a kind of column or cylinder, whoſe diameter is exceedingly ſmall and ſcarce perceivable. Therefore in ſuch circumſtances there cannot be any ſenſible exploſion, as there is no ſenſible convergency.

PROPOSITION XIV.

THE greateſt exploſion, in certain circumſtances, is from poliſhed ſurfaces of metal; and this exploſion is greater the larger the ſurfaces are, to a limited degree.

LET the point of a needle not electrified, be brought near another of the ſame kind which is electrified, and no exploſion will be perceived, even though the room be darkened. If inſtead of theſe very fine points you take other non-electric bodies which have points not ſo very fine, there will inſue a very ſmall exploſion; and if the non-electric bodies have obtuſe terminations, the exploſion will be more apparent. But the greateſt exploſion is from large poliſhed ſurfaces of metal brought towards each other in like manner, provided the corners or edges of theſe poliſhed ſurfaces are rounded off, or covered with wax.

THIS holds only to a limited degree; for on making uſe of very large ſurfaces, we have not

 found

found the explosion to be increased in proportion.

PROPOSITION XV.

As it has been proved by experiments vii. and viii. sect. iii. that the electric effects are always proportional to the density of the accumulated electric matter, and as those effects are greatest in the densest bodies in their natural state, those bodies must be capable of receiving a greater quantity of electric matter, or in other words, of having the electric matter accumulated to a greater degree, than bodies which are rarer.

For when the vial V is filled with ashes, saw-dust, or cork, and electrified, the accumulation of electric matter will be less, than when the vial is filled with Venice turpentine, and less when filled with Venice turpentine, than with filings of iron, granulated lead, or quicksilver: supposing the electrifying power of the apparatus the same in each experiment, and the wheel turned an equal number of times. For the explosion is greater from the filings, granulated lead, or quicksilver, less from the Venice turpentine, and least of all from the ashes, cork, or saw-dust. So also the painful shock on a person's completing the circuit, is greater from the filings, granulated lead, or quick-

quickſilver, leſs from the Venice turpentine, and leaſt from the cork-aſhes or ſaw-duſt.

AGAIN, if different ſpheres of metal, ivory, wood, and cork, but of equal diameters, be ſuſpended on the bar and electrified, the largeſt exploſions will be from the metal ſpheres, and the leaſt from the wood and cork.

PART

PART II.

SECTION VIII.

IN this part we ſhall firſt give a ſhort account of the *æther* Sir *Iſaac Newton* has treated of, and endeavour to ſhew, that the ſubtile fluid which he calls *æther*, and that which we have been ſpeaking of, are one and the ſame. Then prove, that *light* is lodged in all bodies: and that, the denſer bodies are, the greater is the quantity of *light* contained in them. Laſtly, by the properties ariſing from the mutual action between *æther*, *light*, and *bodies*, we ſhall endeavour to ſolve ſome of the moſt remarkable effects of electricity: and attempt to confirm Sir *Iſaac's* doctrine of *gravitation*, *cohæſion*, &c.

SIR *Iſaac Newton* ſuppoſes that there is an exceedingly ſubtile and elaſtic fluid, which readily pervades all bodies, and is by its elaſtic force expanded throughout the univerſe: that its elaſtic force in proportion to its denſity is immenſely greater, than the elaſtic force of the air compared with its denſity: that the in-

crement of the denſity of this fluid, in receding from a body, is as the quantity of matter in the body directly, and as the ſquare of the diſtance from the center of gravity inverſely.

To illuſtrate this increment of denſity, ſuppoſe the whole force of any globe to be contracted into a point A fig. 12. and a, b, two particles of *æther* placed at an exceeding ſmall diſtance from each other. Suppoſe c, d, two particles alſo of *æther*, placed at an equal diſtance from each other. Then the diminution of denſity is ſuch, that if a particle of matter B was placed between a, b, and another equal particle of matter C, between c, d; no regard being had to the quantity of matter in the particles B and C, the exceſs of force wherewith b preſſes the particle B more, than it is preſſed by a, is to the exceſs of force wherewith d preſſes the particle C more than it is preſſed by c, as the ſquare of the diſtance A C, is to the ſquare of the diſtance A B.

This fluid, which he calls *æther*, he ſuppoſes it to be denſeſt in empty ſpaces, and rareſt in the denſeſt bodies. And in bodies of different denſities, he ſuppoſes it to be rarer in denſer bodies; and denſer in rarer bodies.

He

He likewise supposes that *light* enters the composition of all bodies, and that by the mutual action of the *æther* without the bodies upon the *æther* and light within bodies, a very dense graduated medium of *æther* is caused, which surrounds their surfaces to very small distances; and may be of different density, according to the quantity of light in each body. This graduated medium of *æther*, he seems to think, is the cause of the reflection, refraction, and inflection of light (see *Opt.* page 241.) also of cohesion, fermentation, &c. For a more particular account of this, and how gravitation is caused, we refer to a *Dissertation on the æther*, by Dr. *Bry. Robinson.*

The electric matter has been proved in the first part of this treatise to be exceedingly subtile and elastic, and to be contained in all bodies we are acquainted with. And there is reason to think that it is densest in spaces void of grosser matter, as we shall endeavour to shew more fully hereafter from experiment and reason. Since therefore in these properties it strongly resembles the *æther*, we may look upon it as the *æther* joined with grosser particles of matter propelled from bodies by the force and vigour of its action.

COROLLARY I.

FROM the *æther's* being denſeſt in the rareſt bodies, and rareſt in the denſeſt bodies, it follows, that, if a body be made rarer by any means whatſoever, the *æther* in that body muſt grow denſer. Becauſe the parts of the body are removed to a greater diſtance from one another. And conſequently the pores or vacuities in that body will be larger.

COROLLARY II.

AND if a body be made denſer by any means whatſoever, the *æther* in that body will grow rarer, becauſe the parts are brought nearer together: conſequently the pores or vacuities in that body will be ſmaller.

COROLLARY III.

FRICTION will cauſe bodies to rarefy as well as the heat of the ſun, or any other heat; and thoſe rarefied bodies will contract and grow denſer on diſcontinuing the friction, or on removing their rarefied parts from the friction.

COROLLARY IV.

HENCE it is evident, that as bodies grow rarer by heat, *æther* flows into them from other bodies; and that as they grow denſer by cold, *æther* flows out of them into other bodies. So that the denſity of the *æther* in any particular body, is as the mean denſity of all other bodies in proportion to the denſity of that

that body. And therefore the density of the *æther* in any particular body will be increased, when any other body or bodies are condensed, or when that body is rarefied. And on the contrary, the density of the *æther* in any particular body will be lessened when any other body or bodies are rarefied, or when that body is condensed[a].

PROPOSITION XVI.

When two bodies are rubbed against each other, the *æther* will flow in greater quantity into the rarefied parts of the bodies, than into those parts of the same bodies which are not rarefied: and that in a different degree as the parts of the bodies are more or less rarefied. And upon the parts of the bodies growing denser, the *æther* must pass out of the bodies where it meets with the least resistance.

We have shewn from several experiments which follow the vii[th] proposition, that different bodies obstruct the passage of the electric matter with different degrees of strength.

If now it be true, what Sir *Isaac Newton* seems to think (and what we hope we shall be able to confirm hereafter from experiments) that there actually surrounds all bodies, to very small distances, a very dense graduated atmo-

[a] See Dr. *Robinson's* Answer to a pamphlet intituled, *Remarks on Dr. Robinson's System of Muscular Motion.*

ſphere of *æther* of different degrees of denſity, ariſing from the different denſities of the bodies, and the different quantities of light contained in them, it will be eaſy to conceive how the *æther* may be retained within a body by the ſurrounding denſe atmoſphere of the *æther* obſtructing or reſiſting in ſome meaſure its *exit* out of the body: and how ſome bodies which have this atmoſphere denſeſt, retain the accumulated *æther* longer than others which have it leſs denſe. Such bodies are glaſs, amber, wax, reſin, glue, and other electrics: for they, when electrified, will continue to act upon light bodies much longer than iron, and other non-electrics, when electrified. And for the ſame reaſon, glaſs, amber, wax, and other electrics, muſt be leſs capable of receiving the *æther* by communication, than metals and other non-electrics.

From the ſame principle we may conceive how the *æther* gains admittance through the ſmall ſurrounding denſe atmoſphere of *æther*, into the body where it is to be accumulated.

For when the parts on the ſurface of the body G are rarified, that part of the denſe atmoſphere of *æther* which we ſuppoſe extended over the rarefied parts, muſt be rarefied alſo: and ſince that is the caſe, the obſtruction or reſiſtance given to the entrance of the

æther

æther into G, muſt thereby be leſſened. Conſequently if there be a flux of *æther* from C towards that part of G thus rarefied, the paſſage or entrance into G will thus be more eaſy.

Let us now inquire how a flux or flowing of the *æther* from the parts adjacent can be cauſed. And again, how it eſcapes into other bodies, and why friction only can produce theſe effects.

Suppose the cuſhion C, which is to rub the cylinder G, to be one uniform denſe body, of a given magnitude. And ſuppoſe the *æther* in that body, before any part of the body is heated more than another, to be of an uniform denſity. Let the cuſhion C be placed, along with the cylinder G, on a body which has the denſeſt atmoſphere of *æther* ſurrounding it: for example, wax or glaſs, R, as in the experiment following the iv[th] propoſition. This being done, rarefy part of the ſurface C by rubbing it againſt G, and G will be rarefied alſo. The parts of both bodies being thus rarefied, the *æther* muſt grow denſer in thoſe rarefied parts than it was before by coroll. i. but the whole quantity of matter in the glaſs G is leſs than the whole quantity of matter in C, therefore (ſuppoſing no *æther* to flow from any body or place that lies without thoſe bodies G and C) the *æther* in thoſe parts of the bodies

which are not rarefied, muſt flow into their rarefied parts, by coroll. iv. And if a quantity of *æther* proportional to the rarefaction of the bodies, paſſes into the rarefied parts, it is evident that a greater quantity of *æther* muſt flow from C than G, before the *æther* within them, or in the parts which are not rarefied, is attenuated or rarefied to an equal degree in each.

Now, though the *æther* be denſer in the rarefied parts of the bodies C and G, than it was before the friction, yet as the reſiſtance given to the exit of the *æther* at thoſe rarefied parts by the graduated atmoſphere, is leſſened, on account of the friction, the *æther* contained not only in thoſe rarefied parts, but in the other parts of the body, may, by the appoſition of a non-electric, paſs off more readily than it otherwiſe would have done, and the quantity of *æther* in the whole body may thereby be leſſened.

In this caſe we ſuppoſe the flux of the *æther* from the circumambient bodies is in a great meaſure prevented, and therefore as the expanſive force continually decreaſes, the iſſuing of the *æther* muſt alſo gradually leſſen, and in a ſhort time totally ceaſe.

This quantity cannot be leſſened beyond a certain degree, becauſe a certain quantity is re-

2 quiſite

quisite to overcome, by its expansive force, the resistance given to its *exit*.

This is confirmed by experiment: for when the machine is set upon wax, we are not able to produce any more electric matter than a very small quantity, though the friction be continued for any length of time. See experiment following proposition iv.

On adding more matter to C, the quantity of *æther* is increased, and consequently a greater quantity must pass off, than in the last experiment, before it arrives at the same degree of attenuation or rarefaction. This is also confirmed by experiment. See proposition iv.

Hence we may see the reason why, when so large a mass of matter as the whole earth is added, it is not in our power to attenuate or rarefy the *æther* in it to any sensible degree: And why the electric effects in this last case are so much greater than in the preceding ones.

For the magnitude of the earth being immensely greater than the magnitude of the bar, the *æther* must flow in as great a quantity from the earth into C and G, as it passes from them into the bar, even though the friction be continued ever so long.

The first experiment in section ii. confirms this, as well as the experiment following the

ivth proposition: for when any non-electric communicates with C and the earth; or the wax R is taken away, there will be a continual issuing of the electric matter from the bar, and that for any length of time.

THE flowing of the *æther* must continue so long as the friction, because the rarefied surface of the glass G removing every instant from the cushion, begins to cool and contract; so that the *æther* which flowed from C into the rarefied parts of the glass G must now pass away where the resistance to its *exit* is the least; which will be found to be in the wires w w. For the opposite or inner side of the glass G, together with the air contained in the cylinder, resist the *exit* of the *æther* more than the wires w w, in contact with the outer side, as it will be proved by experiments hereafter. And it cannot pass back again towards C, because the parts of the glass G at or near C, are more rarefied, than those parts of G that are farther removed from C. Neither can the *æther* pass into the air so copiously, as into the wires, it appearing from all the preceding experiments that air resists its exit more than grosser bodies.

FRICTION only then can cause these effects, as it gives the *æther* in the rarefied parts of the glass an opportunity to escape every instant into

other

other adjacent bodies where the resistance to its exit is the least. For the parts of the glass that are most rarefied, are moved from the friction of the rubber every instant. And therefore such bodies that resist the passage of the *æther* least; and happen to be nearest G as it turns round, must receive most of the *æther* that issues from G.

COROLLARY I.

HENCE we may see the reason why upon turning the rarified parts of the glass from the wires w w, as in the experiment following proposition i, the electric effects in the bar are considerably less. For in that experiment part of the electric matter passes into the frame of the machine.

COROLLARY II.

AND hence we may perceive the reason why equal effects can never be produced in the bar BB from the cushion and the glass, without friction; even though they are heated to any degree whatsoever, by the fire or the sun. See experiment i. section ii.

COROLLARY III.

HENCE also we may understand how it is that the flowing of the *æther* gradually lessens, and at last ceases on discontinuing the friction. And how the electric effects from the glass

grow

grow weaker as it cools and recovers its original state.

Corollary IV.

Hence likewise we see the reason why two thick electrics rubbed against each other can never produce so strong effects as an electric and a non-electric body. And therefore why setting the machine on non-electric bodies, moistening the leather of the cushion (which when dry is in some degree an electric) and all other circumstances to keep an open communication with the cushion C, are absolutely necessary for producing the greatest flux of the *æther*. This agrees also with the first corollary to proposition iv. And again, why silk or hair lines, glass, amber, wax, resin, pitch, glue, and all other electric bodies which obstruct or resist the exit or entrance of the *æther* more than metals or other non-electric bodies, are the only bodies absolutely necessary to hang or set non-electric bodies upon, in order to see how far the *æther* is capable of being accumulated in any non-electric body in such particular circumstances. And why those last mentioned bodies should be always dry and free from dust and dirt. All which things are agreeable to what we have advanced in the first section.

Pro-

PROPOSITION XVII.

WHEN the *æther* is put into ſuch a motion within a body as in the laſt propoſition, it will throw off, by the violence of its action, ſulphur, and other matter lodged on the ſurface or within the pores, where it is leſs intimately combined with, and united to the parts of that body.

FOR the electric matter, in paſſing out of bodies, is generally obſerved to be of a ſulphurous nature from its ſmell. And if a hand, or any other part of the body be held for ſome time in the ſtream of the electric matter as it iſſues, the hand, or that part which is oppoſed, will acquire the ſame kind of ſmell: nor will it preſently loſe that ſmell. The ſame effluvia will likewiſe whiten red roſes, as ſulphurous ſteams are known to do [a].

COROLLARY I.

HENCE the roſe and hand ſeem to be a kind of ſtrainers by which the more groſs ſulphurous and other particles are ſeparated from the more fine and ſubtile ones of *æther*.

COROLLARY II.

FROM this ſulphurous matter condenſed in the focus along with the *æther*, and fermenting

[a] The whitening of red roſes, by placing them in the ſtream of the electric matter, was obſerved by Dr. *Bevis*.

with

with the nitrous acid floating in the air, it is probably that the sudden blast or violent explosion in electrical experiments is produced [a]: in like manner as Sir *Is. Newton* has observed that lightning, thunder, and fiery meteors are caused by sulphurous steams fermenting with that acid; for, says he, the air abounds with acid vapours; as appears by the rusting of iron and copper in it, the kindling of the fire by blowing, and the beating of the heart by means of respiration.

[a] That air is necessary for the production of these effects, appears from many experiments; for if two non-electric bodies be included in a glass receiver exhausted of air, or to as great a degree as we are yet able, and one of those bodies afterwards electrified, on their being moved near each other there will insue no explosion like that we perceive when the air is not exhausted; but there will appear a faint light between the bodies, and this is only visible when the experiment is made in a dark place. This faint light seems to require a certain quantity of air within the glass; for it is most visible when the air is not rarefied to so great a degree as we are able.

That an acid in the air is requisite to produce the greatest explosion, appears from the experiments made when the wind blows northerly or easterly. For the effects are then greatest with respect to the explosion. And it is generally admitted, that the air abounds more with acid when either of those winds blow than when any other wind blows.

Again, when the air abounds with sulphur, as in hot weather, and when there is thunder and lightning, the explosion in electrical experiments is least.

We

We will illuſtrate this matter farther by the following experiments.

A lighted candle will go out, and glowing coals ceaſe to ſhine in the air pump on drawing out the air: nay, red hot iron will ceaſe to ſhine in a ſhort time, upon exhauſting the receiver of air. Again, a candle will go out, glowing coals and red hot iron ceaſe to ſhine in a ſmall quantity of air ſo cloſely confined as to have no communication with the reſt of the atmoſphere. If two parts of a compound ſpirit of nitre (which is a ſtrong acid ſpirit) be poured on one part of oil of cloves, or carraway ſeeds, or of any ponderous oil of vegetable or animal ſubſtances, or oil of turpentine, thickened with a little balſam of ſulphur, the liquors grow ſo very hot in the mixing as preſently to ſend up a burning flame. If a drachm of the ſame compound ſpirit be poured upon half a drachm of oil of carraway ſeeds, even in *vacuo*, the mixture immediately makes a flaſh like gunpowder. And well rectified ſpirit of wine poured on the ſame compound ſpirit flaſhes. Common brimſtone and nitre powdered, mixed together, and kindled, will continue to burn under water, or in *vacuo*, as well as in the open air.

SECTION

SECTION IX.

WHEN we hereafter ſpeak of electric matter, we would be underſtood to mean the *æther* put into ſuch a motion within a body, as to carry along with it ſulphur and other groſs matter. But when we ſpeak of the *æther*, we mean the ſame fluid, but not put into that degree of motion.

LIGHT is proved by Sir *Iſ. Newton* to conſiſt of particles of various ſizes: but the particles of *æther*, he ſays, are exceedingly ſmaller than thoſe of light.

PROPOSITION XVIII.

ÆTHER is more ſubtile than light.

FOR if *æther* and light are put into ſuch a motion, as to be propagated to immenſe diſtances in a ſhort ſpace of time, and the particles of one of them continue to move on with an equal, or rather with an accelerated motion through the moſt denſe bodies interpoſed (ſee experiment x. ſection iii.) whilſt the particles of the other are either abſorbed, or ſtopt by ſuch interpoſition, or reflected from their ſurfaces; it follows that thoſe particles which paſs through the interſtices of bodies, are more ſubtile than thoſe which do not paſs.

But

But *æther* has been proved to paſs through denſe bodies, which light will not paſs through, therefore *æther* is more ſubtile than light[a].

THE velocity of light is exceeding great, and though the particles conſtituting the different rays are of various ſizes, yet they all deſcribe equal ſpaces in the ſame time. To account for the propagation of light from the ſun to us, in ſo ſhort a time as ſeven or eight minutes, various have been the hypotheſes framed. All theſe Sir *Iſaac Newton* has endeavoured to ſhow, in queſtion xxviii. to be very erroneous, and from the force of reaſon joined to obſervation and experiments, ſubſtituted the *æther* we have ſo often mentioned, and this at a time when electricity was but little known.

PROPOSITION XIX.

DENSE bodies contain more light in their compoſitions than rare bodies, unctuous and ſulphurous ones excepted.

THIS appears from their emitting light more copiouſly when their parts are ſufficiently agitated,

[a] It may be reaſonably objected, that this propoſition is by no means ſufficiently proved, ſince light will paſs through glaſs, amber, gums, &c. which the *æther* will not, or, however, from what has hitherto appeared. For an anſwer to this, we refer to the remainder of this treatiſe, and particularly propoſition xxvii. and xxx. where we undertake to ſhew that all bodies may be electrified.

tated, whether that agitation be made by friction, percussion, or putrefaction, or any other cause. For instance, dense bodies which refract and reflect light most strongly when exposed in the summer sun, acquire a greater heat by the action of the refracted or reflected light; and if the heat be increased till it be about four times hotter than boiling water, then such dense bodies will emit light so copiously as to shine.

PROPOSITION XX.

SUCH bodies as are unctuous and sulphurous have more light in their composition than others of the like density.

The more copious the emission of light is from bodies, when their parts are agitated, the greater is the quantity contained in them.

Now sulphurous bodies, acted upon by the rays of light collected into a focus by a lens flame, burn more vehemently than others of the same density that have less sulphur in them, or, in other words, emit more light; and must therefore have more light in their compositions.

COROLLARY.

SINCE all bodies refract, reflect, and inflect light by one and the same power, and their power of refraction is nearly as their densities, their

their power of reflection and inflection must be in the same proportion.

The quantity of light too in their composition is for the most part as their densities. It seems to follow then, that the power in bodies to refract, reflect, and inflect the rays of light, is nearly proportional to the quantity of light contained in them.

PROPOSITION XXI.

The inflective, refractive, or reflective power of a body extends itself but a very small distance from the body.

For the rays of light in passing by bodies are not affected so as to be turned out of their rectilineal course, till they are very near the edges. *Vide Newt. Opt.* III. L. The cause of this power or medium, which surrounds all bodies, remains to be enquired into.

1. The law established between the *æther* and bodies, for making the *æther* the cause of most of the phænomena of nature, respects both the quantity of matter and the quantity of light contained in bodies.

2 That part of the law which respects only the quantity of matter, we have given before, which in other words amounts to this: The body and the *æther* lying next to it all round, repel one another with a force which

is measured by a rectangle under the quantity of matter in the body, and the density of the *æther* applied to the square of the distance of the surface from the center of gravity of the body. If the body be a globe of an uniform density throughout, in which case the center of the globe will be its center of gravity, the *æther* will press on the globe by endeavouring to expand itself, and by that pressure it will recede from the globe, and its density will continually increase, and the increment or increase of density at any distance, will be as the quantity of matter in the globe directly, and the square of that distance from the center of the globe inversely. If the globe be large, the sphere of *æther* surrounding it, whose density thus increases, will be large; and the sphere of *æther* will be small if the globe be small. The sphere of *æther* surrounding the sun, occasioned by the action of that great body, extends much beyond Saturn, nay, beyond the distance of the remotest of the comets aphelium. The sphere of *æther* surrounding the earth occasioned by the action of the earth on this medium extends itself beyond the moon. Hence any body placed within a sphere of *æther* belonging to the sun, earth, or any other great globe will move towards it, the *æther* being denser on the remoter side of each particle of the

body

body than on its nearer ſide, with reſpect to the globe: if the globe be ſmall, the ſphere of *æther* ſurrounding it will be ſmall; and the increment of the denſity, which at the ſurface of a globe is as at its diameter and denſity taken together, may be ſo very ſmall as not to be able to produce any ſenſible motion in a ſmall particle placed within the ſphere of that ſmall globe. The increment of the denſity of the *æther* at the ſurface of a globe of a given denſity, being as the ſemi-diameter of the globe: and the ſemi-diameter of the earth being 3965 engliſh miles, or 251222400 inches, the increment of the denſity at the ſurface of the earth, and at the ſurface of a ſmall globe of the ſame denſity with the earth whoſe ſemi-diameter is 1 inch, will be 251222400 and 1 the ſpaces deſcribed in 1″ by a corpuſcle moved by theſe forces will be 193 inches and $\frac{1}{1301670}$ part of an inch. Hence the corpuſcle moved by the force of the little globe will be above 15 days in deſcribing 1 inch, and conſequently the force of gravity in the ſmall particles of matter is altogether inſufficient for producing the violent motions thoſe particles have in fermentation.

THAT part of the law which reſpects light reaches but to a very ſmall diſtance from the ſurface of bodies, and ſuch as is mentioned in

the last proposition. The light which enters the composition of all bodies by powerfully repelling the adjoining *æther*, and thereby increasing its density to a very small distance (suppose to the eight hundredth part of an inch) from the surface of bodies, constitutes this force. That light and *æther* act with immense force on one another, appears from the rays of light (which move above 158000 English miles in a second of time) being turned out of their rectilineal course by the *æther* at the surface of bodies; for it requires an immense force to turn a body moving with so great a velocity out of a rectilineal course. Light and *æther* repel one another very strongly, and hence it is that light adhering to the surface of bodies, repels the adjoining *æther* with great force, and thereby causes a great and quick increase of its density to a small distance from the surface, such as is represented by fig. 13. from the particle or body A to b; at the end of this distance from the surface, that is, at b, the *æther* is densest: and much denser than it would be from the quantity of matter in the body. The force of light terminating at this distance, the *æther* condensed by that force will afterwards relax and rarify to some certain distance, suppose at c, and beyond that distance it will go on to be condensed by the sole action

of

of the quantity of matter in the body to d, and beyond. The condenſation and rarification of the *æther* at the ſurfaces of bodies conſtitute two forces, an impulſive force, which is from b to the body A, and a repulſive force, which is from b to c; thoſe forces act very powerfully on minute particles which come within the limits of their action. Hence theſe forces are ſtrongeſt in bodies which contain moſt light in their compoſition with reſpect to their denſities, that is, they are ſtrongeſt in ſulphurous and unctuous bodies.

The narrow limits of the two forces conſtituted by light prevent them from affecting bodies of any ſenſible magnitude, for bodies muſt be ſo ſmall as to fall within theſe limits before they can be moved by theſe forces. A body leſs than the eight hundredth part of an inch in diameter, ſuppoſe a (fig. 14,) placed between the denſeſt part of the *æther* b and the ſurface of the body x, will move towards the body x by receding from the denſer part of the *æther* towards the rarer. The ſame ſmall body a, placed beyond the denſeſt part of the *æther* b of the body x, will move from the body x by receding from the denſer part of the *æther* towards the rarer. So that when the denſeſt part of the *æther* b, cauſed by the ſuperficial light of a body, falls without a ſmall particle

a, (fig. 14) that particle a will move towards the body x: and if x be equal to a, they will move equally faſt towards each other; and they will move from each other if the denſeſt part of the *æther* b, c, lie between the particles x and a, (fig. 15) or in other words if the particles are placed any where within the bounds of their repulſive forces.

The rays of light ſeem to be reflected regularly by virtue of this medium evenly diffuſed all over the ſurface of a poliſhed body. " Sir *Iſaac Newton* ſays, " were the rays of light " reflected by impinging on the ſolid parts of " bodies, their reflections from poliſhed ſur" faces could not be ſo regular as they are. For " in poliſhing glaſs with ſand, putty, or tri" poly, it is not to be imagined that thoſe ſub" ſtances can by grating and fretting the glaſs " bring all its leaſt particles to an accurate po" liſh; ſo that all their ſurfaces ſhall be truly " plain, or truly ſpherical, and look all the " ſame way, ſo as together to compoſe one " even ſurface. The ſmaller the particles of " thoſe ſubſtances, are the ſmaller will be the " ſcratches by which they continually fret and " wear away the glaſs until it be poliſhed, but " be they ever ſo ſmall they can wear away " the glaſs no otherwiſe than by grating and " ſcratching it, and breaking the protuber-

" ances,

" ances, and therefore polish it no otherwise " than by bringing its roughness to a very fine " grain, so that the scratches and frettings of " the surface become too small to be visible. " And therefore if light were reflected by im- " pinging upon the solid parts of the glass, it " would be scattered as much by the most po- " lished glass as by the roughest." For these rays only which fall upon the tops and bottoms of the protuberances and cavities would be reflected according to the general direction of the whole surface of the body: those which fall upon the oblique sides of those protuberances would be reflected in a different angle.

THAT medium which we have shewn to surround all bodies to very small distances, and which is supposed by Sir *Isaac Newton* to be the cause of the reflection, refraction, and inflection of light, we shall call by the different names of the reflective refractive, or inflective medium, or in one word by *atmosphærula*, as will best suit our present purpose.

SECTION X.

PROPOSITION XXII.

THE *atmosphærula* surrounding any body prevents the electric matter, when accumulated within that body, from issuing so fast as it otherwise would, if there was no *atmosphærula* surrounding it.

For the electric matter, its expansive force being equal at every point of the surface of a body electrified, ought to expand itself and be propagated equally from all parts of the body into the air; and that as fast as it enters into the body: so that there could be no accumulation of the electric matter, (See Sect. iii, Experim. 7.)

But it is found that a globe of metal will continue electrified for some time; and that if a pointed piece of metal be fixed to it, the globe will not continue so long electrified: and the electric matter will issue most from the point. Whence it appears that there is something acting at the surfaces of bodies which retards the exit of the electric matter: and that more or less according to the circumstances which attend

tend the experiment. What this cauſe is, we ſhall now inquire.

The preſſure of the air upon the ſurfaces of bodies cannot be the cauſe; for the preſſure of the air on any given part of the ſurface of a pointed body muſt be equal to the preſſure on an equal given part of the ſurface of any other body which is not pointed: and the preſſure being equal in both theſe caſes, the electric matter ought to meet with an equal reſiſtance from the air. Yet notwithſtanding we find that the electric matter paſſes off ſooner from pointed bodies than from bodies that are not pointed: and that the diſſipation is performed in the ſhorteſt time when the points are the fineſt. Beſides, this holds equally true *in vacuo:* and therefore thoſe effects may ariſe from the *atmoſphærula* being rarer at a point, than at the ſurface of a body.

If this ſuppoſition be true, it follows, that the rarer the *atmoſphærula* is, the leſs will be the reſtance to the exit of the electric matter. Now the finer points are, the more copious is the iſſuing of the electric matter from them; therefore the propoſition is true.

PROPOSITION XXIII.

THE electric matter upon its iſſuing ſuddenly through a denſer *atmoſphærula* produces a greater effect than when it iſſues through a rarer.

TO any part of the wire w (fig. 16.) fix a very thin piece of hard wax, glue, *Muſcovy* glaſs, or common glaſs G in the middle, or which will anſwer better, a piece of gilt leather three or four inches in diameter; then when the vial V is electrified, bring the diſſipator D towards the middle of the affixed body G, and the exploſion will be much louder than it would be from any part of the wire w, ſuppoſing the vial electrified to the ſame degree.

N.B. THE leather muſt be varniſhed on the gilt ſide, and the edges of it covered with ſealing wax.

IN this experiment the action of the electric matter is ſo ſtrong as to make a hole through the leather, and to force quite away the varniſh and ſilver, ſo as to leave the leather for ſome little ſpace round the hole quite uncovered. It is remarkable that the ſpace ſtript of the varniſh is greater than the ſpace ſtript of the ſilver.

If the wax, or very thin glaſs be made uſe of in the above experiment, the violence of the action of the electric matter will break it.

PROPOSITION XXIV.

In two or more circuits made at the ſame time, with the ſame vial, but with different bodies, the electric effect, ſuppoſing the filings in the vial ſtrongly electrified, will be in that circuit only where the electric matter will meet with the leaſt reſiſtance.

Proof by Experiments.

Experiment I.

To the loop x (fig. 17.) on the covering of the vial V, faſten one end of a wire C of any length, ten, a hundred, or a thouſand yards, for it appears to be the ſame thing in the event of this experiment, and when the vial is electrified as uſual, let the perſon P, who makes the experiment take hold of the vial V or the wire C at x, in one hand, and with the other hand H, laying hold of the other end of the wire c, bring that end of c towards the wire w, which is in the neck of the vial. By this means there will be two circuits made, as may be eaſily ſeen by the figure, the one with the wire and vial VCHW: and the other by the Perſon and vial VPHW. In ſuch circum-

stances, the person will not feel the electric effect, or in other words, receive a convulsive shock, as the resistance arising from the *atmosphærulæ* is less on the surface of the wire C, than in the person. This is manifest from reason as well as experiment; for the parts of the wire C are supposed to be incontact from end to end, so that there can be only the resistance arising from two *atmosphærulæ* to be overcome, namely, that at each end. Whereas in the person there are different kinds of matter distinct from one another, namely, the fleshy, bony, and nervous parts, besides the blood and other fluids, which have their different *atmosphærulæ*. But as it may seem difficult to conceive how bodies included within, or surrounded by other bodies in like manner as the nervous, fleshy, and other parts of animal are, should have their different *atmosphærulæ* surrounding them, we shall set down an experiment that will serve to illustrate this matter.

EXPERIMENT II.

POUR an ounce or two of well dissolved Venice turpentine into a thin glass cup, and afterwards pour two or three drops of milk, which has had the cream taken off, into the turpentine, in one part, and two or three drops into another part of the same cup, so that there may be two separate quantities, or drops of milk in the

turpentine; then turn the cup different ways, till the drops are brought as near together as you are able; for they will not mix till a considerable time after; then ſhake the cup, or let one drop preſs upon the other: and you will perceive an actual diſtance, though very ſmall, between them: and the drops will be convex and concave to one another, and have their edges turned up like lips. Shake them again, and you will ſtill find them to keep the ſame diſtance from one another, and retain ſomething of the ſame figures. If the turpentine be not ſhaked for about fifteen or twenty minutes, the two drops will come together ſo as to make but one.

Query. If the *atmoſphærula* ſurrounding thoſe drops of milk in the Venice turpentine be not the cauſe of this phænomenon, how comes it that the drops ſhould keep at a diſtance from one another and retain thoſe ſingular forms, even though they lye upon one another?

Now, according to this reaſoning, when the reſiſtance ariſing from the *atmoſphærulæ* in the perſon is leſs than in the other circuit, the electric effect ought to be felt in the perſon.

And that this is the caſe will appear from the following experiment.

Expe-

EXPERIMENT III.

LET one end of a clean unrusted chain (for example, such a one as is commonly used for a jack) and of the same length with the wire c, laying loose or unstretched, be fixed to the vial at x, and the other end be brought round by the person to the wire w, as the wire c was before in the first experiment, proposition xxiv. And the electric effect will not be in the chain but in the person, and to much the same degree as if no chain was made use of.

IN this last experiment, we consider each link of the chain as having two separate *atmosphærulæ*; for if any thing should pass or be propagated through each link, it must pass or be propagated through two *atmosphærulæ* in each link: one as it enters, the other as it passes out; and upon supposition that the sum of these *atmosphærulæ*, and the resistance arising from them added together, exceed the sum of the *atmosphærulæ*, and the resistance arising from them in the person, the electric effect must be in the person, or where the resistance is least.

EXPERIMENT IV.

AGAIN, shorten the chain, and thereby lessen the number of *atmosphærulæ*, till such time as the resistance arising from the *atmosphærulæ* in the person added together, exceed the resistance

ance arising from the *atmosphærulæ* of the chain added together, and the person in these circumstances will not be affected. Nor indeed will the person be affected when a chain of any length is made use of, provided it be stretched tight, so that the links may be nearer contact with each other [a].

COROLLARY.

THEREFORE different pressures of the links against one another, whether it be caused by the weight of the chain, or by pulling it, will produce very different effects.

EXPRRIMENT V.

THOUGH the electric effect be perceived in the person when there are two circuits performed, and the chain of a considerable length, and unstretched: Yet if one circuit only be performed, and that with a chain unstretched, the electric effect will be in the chain: as appears by the great explosion, and the many small ones between the links from end to end, which may be seen when there is but little light in the room. These small explosions do not appear between the links in the other experiments.

[a] Mr. *Watson*, in the presence of several gentlemen of the *Royal Society*, tried some experiments with a vial and a wire two miles in length, in order to determine the velocity of the electric matter.

EXPE-

EXPERIMENT VI.

AGAIN, if the unſtretched chain and a wire of an equal length make up the circuit at the ſame time, in the manner we have deſcribed above, the great exploſion will enſue, but none of the ſmall ones will be ſeen between the links of the chain.

FROM this laſt experiment we conclude, that the effect was along the wire in which was the leaſt reſiſtance, or the feweſt *atmoſphærulæ*.

IF the reſiſtance ſhould be the ſame in all the circuits, whether there are two or more, it is eaſy to conceive, they will all be affected alike.

WE have an experiment of this kind [b]. It is performed in the following manner.

EXPERIMENT VII.

LET the vial V (fig. 18.) be electrified, and placed upon a metal plate P, and let ſeveral perſons, three, four, five, ſix, or more, each of them take hold of the plate with one hand, and of a bar of irron d d, with the other: then let them move either the end or the middle of the bar d d towards the wire w, which paſſes into the vial, and they will every one be affected alike with a painful convulſive ſhock. Let them change places, and let the vial be electrified again, and the effect will be the ſame.

[b] This experiment was communicated to me by the late Mr. G. *Graham*.

SECTION

SECTION XI.

PROPOSITION XXV.

AS all groſs bodies have their *atmoſphærulæ* ſurrounding them, ſo it is probable the particles of air, which are heterogenious (or a collection of many kinds of bodies) have *atmoſphærulæ* ſimilar to the ſame kind of bodies, which are groſſer and larger.

FOR all bodies, whether ſolid or fluid, have their *atmoſphærulæ* by the vii^th^, viii^th^, and ix^th^ ſections, which *atmoſphærulæ* will be (excepting ſuch bodies as abound with unctuous particles) nearly proportional to their denſities, by propoſition xviii. ſection ix. So that if a ſolid or fluid be divided or ſeparated into any number of parts, each part having light in its compoſition, may, by the action of that light upon the *æther* without, have an *atmoſphærula* conſtituted. All bodies likewiſe, whether ſolid or fluid, may have their parts ſeparated from one another by the action of heat. When the parts of groſs bodies are ſeparated by heat, fermentation, or otherwiſe, and placed without the reach of each other's attraction, then the particles recede from one another, and may conſti-

tute air. When the particles of any body do not cohere ſtrongly, and ſuch is the caſe with fluids, a ſmall heat is ſufficient to ſeparate their parts and turn them into vapours. Groſs bodies are with the greateſt difficulty brought together, and upon contact they cohere moſt ſtrongly. The particles of permanent air ariſing from ſuch groſs bodies by fermentation recede from one another with the greateſt force. And becauſe the particles of permanent air are groſſer and ariſe from denſer ſubſtances than thoſe of vapours, thence it is that true air is more ponderous than vapour, and that a moiſt atmoſphere is lighter than a dry one, quantity for quantity. See *Newt. Opt.* p. 372.

PROPOSITION XXVI.

A SUFFICIENT number of ſuch laſt-mentioned particles, when placed in ſuch a medium as the *æther*, may conſtitute an elaſtic fluid ſomewhat ſimilar to the atmoſphere of our earth.

SUPPOSE any number of groſs particles of different ſpecific denſities, for example, five orders, or degrees: and the firſt order of the leaſt denſity, the ſecond more denſe, the third denſer, the fourth denſer than the third; and the fifth denſeſt. Now ſuppoſe thoſe particles at a given diſtance from the earth to be thrown

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confuſedly into ſuch a medium as the *æther* acting by the ſame law that gravity acts: it is evident that the denſeſt particles will fall and be neareſt the earth; but thoſe particles having *atmoſphærulæ* much ſtronger than the force of gravity, will be kept from being in cloſe contact with the ſurface of the earth. The fifth order then will be neareſt the ſurface, and ſuppoſing thoſe to cover a given area thereof, the fourth, as being next in denſity, will preſs forward, and reſt upon the *atmoſphærula* of the fifth: the third will preſs upon the fourth as the fourth did upon the fifth: the ſecond, as being ſtill lighter, will reſt upon the third, and the firſt upon the ſecond. All theſe will form parallel plains (if the particles in each order are of equal denſities) of an uniform denſity according to the order in which it ranks: the groſſeſt and denſeſt particles, as obſerved above, being next the earth, whilſt the lighteſt will be removed to the greateſt diſtance from it. And as the ſize of the particles of each order muſt be ſuppoſed very minute, and conſequently their *atmoſphærulæ* nearer to an uniformity than if they were ſtill larger, they will be very eaſily moved among themſelves on the leaſt impulſe, and herein they come under the definition of fluids. Suppoſing then ſome particles of the firſt order to be intermixed with others of

of the fifth, according to the laws of hydrostatics they must ascend, as being specifically lighter than those of the fifth, fourth, third, or even of the second order, and acquire so much motion as the access or defect of gravity is able to produce. Again, these particles being very minute may be looked upon as equal in their densities and diameters. Now as the density of air is found to be nearly equal, if not accurately so, to the force compressing it, the elasticity thereof will be in the same proportion, the centrifugal forces of the adjoining particles are reciprocally proportional to the distance of their centers (an elastic fluid, the density of which is as the compression, being composed of such particles, by proposition xxiii. lib. ii. *Newt. Principia*) the particles of *æther* therefore, lying in and between the particles of air, will be subject to the like laws upon compression, and consequently a sufficient number of the abovementioned particles placed in such a medium may constitute a fluid similar to the air in our atmosphere.

PROPOSITION XXVII.

If into a vessel whose *atmosphærula* is very great (for example glass) be put any kind of matter, and that be afterwards electrified, the resistance the electric matter will meet with in

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passing out on compleating the circuit, seems to be as the thickness of the glass, the quantity of non-electric contact with the glass, and the sum of their several *atmosphærulæ*; to wit, of the dissipator, the vessel itself, and the matter contained within it.

By the seventh proposition the electric matter will pass through a glass that is thin, but not through one that is thick [a]. If the glass be very thin, the air alone contained within the glass may be electrified, and a convulsive shock will insue upon a person's completing the circuit. But this effect from electrifying air will not happen if the glass be thick; nay, though it be only of such a thickness as that when filled with filings of iron, it would produce the electric shock. It is plain then, that the thickness of the glass is one circumstance always to be regarded. The quantity of non-electric contact, both on the inside and outside of the vial, is another circumstance to be regarded by proposition ix. That bodies are surrounded by an *atmosphærula* which obstructs the exit of the electric matter, with different degrees of strength, according to the different density of the *atmosphærula*,

[a] To make this experiment, nothing more is required than to take a very thin vial which is dry, and put a cork into the neck thereof, through which cork push the wire w into the vial, and electrify the air within it in like manner as if it was filled with filings, quicksilver, or water.

phærula, appears from proposition xxi. The *atmosphærulæ* of the dissipator may be increased so as to be more in number by proposition xxiii. and made denser or rarer at pleasure, by interposing such bodies as resist the exit or entrance of the electric matter more or less. But supposing the dissipator in these experiments to be one single piece of iron, there will then be only two *atmosphærulæ* to be overcome, together with those arising from the wire w, and the covering of the vial. Therefore the sum of those resisting powers arising from their *atmosphærulæ* are given. And in respect to the latter part of the proposition, since the refractive power of bodies is nearly proportional to their densities, and the refractive power of air in proportion to its density is near that of glass, notwithstanding its rarity: if you take away the air, the resistance which the electric matter will meet with in passing through the glass towards the dissipator will be lessened: because in this case it will only meet with the resistance arising from the internal and external *atmosphærula* of the glass. But on the other hand when air is included within the same vessel, since every particle of air has an *atmosphærula*, the resistance arising from the *atmosphærulæ* of air must be added to the resistance arising from the *atmosphærulæ* of the glass. And therefore the resistance

ance given to the paſſage of the electric matter will be greater or leſs, as a greater or leſs quantity of air is included in the veſſel. This is confirmed by making the experiment.

Lastly, the electric matter will paſs thro' a thicker glaſs filled with filings of iron, ſo as to give the electric ſhock, when it will not paſs through the ſame glaſs filled with air. Becauſe the reſiſtance ariſing from the *atmoſphærulæ* of the filings is leſs than the reſiſtance ariſing from the *atmoſphærulæ* of the particles of the air, as the particles of the filings are larger than the particles of the air; and on that account there are fewer *atmoſphærulæ* to reſiſt its paſſage; therefore the propoſition is true.

Corollary I.

Hence if the vial be very thick there will be little or no accumulation, by propoſition vii. and conſequently no exploſion or convulſive ſhock on a perſon's performing the circuit with his hands, prop. x. experim. 12.

Corollary II.

When the filings of iron in the vial are electrified, upon compleating the circuit three or four times one after another ſucceſſively, without electrifying afreſh, there will be but one large exploſion, and ſometimes will follow two or three very ſmall ones, after which the whole quantity of electric matter will appear

to be dissipated. If instead of iron filings the vial be filled with water, there will issue a greater number of explosions. But the first explosion from the water will be fainter than the first from the filings; and the second and third explosions louder than the second or third from the filings: or in other words, the explosions from the water approach nearer in uniformity to one another, both as to loudness and degree of light, than those from the filings. But when the included air only is electrified, the number of the explosions will be increased further, and their degrees of loudness and light will be still less than in the last case; so likewise they will be more alike to one another as to loudness and degree of light.

QUERY. Do not these phænomena seem to be owing to the different *atmospherulæ* surrounding the particles of water and air, which by their pressing between occasion a greater resistance, and thereby prevent the immediate and total dissipation of the electric matter? For take away the air, and accumulate the electric matter in the vial by the wire w as before, upon compleating the circuit the whole accumulated quantity will appear to be dissipated and lost in one single explosion, which seems to be a strong argument for the truth of what we have advanced. And when a body loses

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any part of its original quantity of electric matter, as in proposition v. may not the electric matter, by reason of the resistance arising from the *atmosphærulæ* of the particles of the air be one, if not the only, cause why the electric matter is not supplied afresh from the air so readily, though more of it be contained therein than in the body? And for the same reason must it not be retained in the body?

SECTION XII.

PROPOSITION XXVIII.

FROM the different density of the *atmosphærulæ* surrounding bodies, it is that some bodies are electric and others non-electric; regard being always had to the texture of the bodies. Such bodies as have the densest *atmosphærulæ* supposing them not fluid, moist, or soft, are called electrics; and those which have the rarest *atmosphærulæ*, non-electrics.

THE truth of this proposition seems evident from what has been said before: for it has been proved that the electric matter passes into or out of those bodies most readily, where the resistance given to its exit or entrance is the least; and the resistance given to the exit or entrance of

of the electric matter has been shewn to arise from the *atmosphærulæ* which surround bodies by section x. and to be in proportion to their different degrees of density. Those bodies therefore whose *atmosphærulæ* are the densest (and such are all electrics by proposition xvi.) have not the electric matter communicated to or accumulated in them to any great degree without friction; whereas those bodies whose *atmosphærulæ* are rare (and such are called non-electrics) will suffer the electric matter to pass readily into, and be accumulated in them, and that to a high degree by communication only [a].

Corollary.

Hence it appears that the resistance given to the electric matter does not absolutely arise from the nature and quality of the internal and constituent parts of bodies, but chiefly from the *atmosphærulæ* on their surfaces. This will appear yet more fully hereafter.

PROPOSITION XXIX.

Any fluid included in a vessel may be electrified, though the *atmosphærulæ* of many fluids

[a] It may be objected that this proposition is not sufficiently proved: for if the *atmosphærulæ* are proportional to the densities of bodies, gold, as it is the densest body, ought to be a strong electric, whereas experience manifests the contrary? In answer to this, see proposition xxx.

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are much denſer than that of common glaſs, as may be gathered from their refractive powers being much greater than the refractive power of common glaſs. This is the caſe with oil of olive, linſeed oil, and ſpirit of turpentine.

THAT all fluids are non-electrics is evident from their being readily electrified, as any one may be convinced by putting the fluid into a veſſel, ſetting the ſame on wax, and letting a wire or any other non-electric touch the bar and the fluid in the veſſel. For upon turning the wheel, the like phænomena may be produced from the fluid, as was done from the bar in the firſt experiment, ſection ii.

BUT that a fluid whoſe *atmoſphærula* is ſo very denſe ſhould be capable of being electrified at all, may ſeem difficult to account for conſiſtent with what is before advanced; to wit, that bodies are rendered electrics by the great denſity of their *atmoſphærulæ*; together with a certain texture of the body. For ſome may aſk, whence it is that linſeed oil ſhould be a non-electric, and glaſs an electric, when the *atmoſphærula* of the former ſeems to be much denſer than that of the latter? To which we anſwer, that from all the experiments we have yet made of bodies being electric, in proportion to the denſity of the *atmoſphærulæ*, this law, which holds true in all ſolid bodies, does not obtain in fluids: one

one reason of which at least may be as follows. That an alteration on the surface of fluid bodies may be caused by the action of the electric matter: so that the *atmosphaerula* may be rendered rarer, or the resistance to the entrance or exit of the electric matter made less; when it may not be the case if the body be solid, it being the property of fluids that their parts should yield to any force impressed upon them, and by yielding, to be easily moved among themselves.

N. B. The blast resembling wind seems to arise from the particles of air being put into a violent rapid motion by the issuing of the electric matter, which must necessarily be greatest at points, edges, or angular terminations, as the electric matter flows through them most readily. That the air is put into such a motion appears from the two following experiments.

Experiment I.

Fig. 19. represents a cork stuck upon a needle, with small bits of paper let into its sides, which serve for fanes; when the other end of the needle is suspended by the magnetic virtue of a load-stone or piece of steel, it may be easily turned round with a very small force. If the cork thus suspended be brought near the point of any body which is electrified, it will be

be turned round very quick, and continue to do so whilst the body continues to be electrified.

EXPERIMENT II.

THE same cork suspended by the magnetic virtue as in the other experiment, when placed in a large receiver exhausted of air, will not have the least rotatory motion, although it be as near the same electrified point as before. But immediately upon suffering a small quantity of air to enter the receiver, the cork will turn round, and continue to do so if the point be continually electrified.

PROPOSITION XXX.

ELECTRIC bodies may be rendered non-electric by heat.

Proof by Experiments.

THIS is the case with wax, pitch, rosin, or glue, when melted. For if in a large iron ladle any of those bodies be thoroughly melted, and the ladle be afterwards suspended with a silk line, or laid upon wax, there being a wire, or some non-electric body so placed, as to conduct the electric matter from the iron bar to the center of the surface of the melted matter, the ladle will be electrified; and an explosion may be produced both from the ladle and the melted matter. But as they grow cold they will be less and less electrified: And when they

are quite cold, there will iſſue no exploſion from either of them; nor will light bodies be moved towards them, as before they would.

Experiment II.

To a glaſs cylinder G (fig. 20.) open at both ends, eight inches long, and about three wide, I fixed at one end a metal plate m, with a ſtrong cement, of ſuch a nature as that the cement would require a greater heat to melt it, than is requiſite to melt either roſin or bees-wax. This I did to prevent ſome melted roſin, which I intended to pour in ſoon after, from running out of the bottom of the glaſs. Into this cylinder I let drop a ſmall piece of metal red hot, in order to keep the melted roſin when poured into the cylinder G from chilling too ſoon at the bottom. I ſet the metal plate, and cylinder thus prepared on the earth, and then filled the cylinder with boiling roſin (the ſurface of which communicated with the bar by means of the wire w) upon turning the wheel and bringing my hand towards the bar no exploſion enſued; though the bar was ſufficiently ſupplied with electric matter, as appeared from the exploſions when the wire was taken away. After ſtaying ſome time till the heat of the roſin was ſomewhat abated, the electric matter began to appear in ſmall exploſions on my approaching the bar, and as the heat

heat ſtill decreaſed the exploſions grew ſtronger; till at length when the roſin was become quite ſtiff, the exploſions were as ſtrong as when the wire and glaſs were removed from the bar.

EXPERIMENT III.

INTO a coated vial of the ſame kind with that we have all along made uſe of, I poured ſome melted roſin (the vial being firſt made gradually hot to prevent it from breaking) till it was nearly filled, and put the wire w into it, then taking hold of the covering of the vial, I electrified the melted roſin that was within the vial, and on compleating the circuit, there iſſued a large exploſion; attended with a convulſive ſhock. As the heat decreaſed, the exploſion and ſhock became gradually leſs; till at laſt I was not able to cauſe any exploſion or ſhock by compleating the circuit.

EXPERIMENT IV.

GLASS, when heated much, is alſo a non-electric. This I tried at a glaſs-houſe by various experiments in the following manner.

HAVING fixed the electric apparatus M, and ordered the wheel thereof to be continually turned, that the electric matter might be continually ſupplied to the bar, I deſired one of the workmen to take out of the furnace as much of the hotteſt melted glaſs with an inſtrument they call a blowing-iron or pipe, as

would cover the end thereof four or five inches thick, and to deliver it to another workman who ſtood upon a board ſupported by bottles. This laſt perſon was continually electrified by means of a wire which paſſed from the iron bar to him, and that in a very ſtrong degree, before he took hold of the blowing-iron with the hot glaſs at the end of it. On my approach towards the thickeſt part of the melted glaſs, with a bar of iron, an exploſion enſued, and that as often as I approached it. But the exploſion became weaker as the glaſs cooled, till at length no exploſion could be produced.

Experiment V.

I now laid the bar of iron in my hand upon the thickeſt part of a freſh quantity of melted glaſs, and approaching with my other hand the blowing-iron which was held by the perſon ſtanding on bottles, no exploſion enſued: but as the glaſs cooled, the electric matter began to appear in exploſions from the blowing-iron; which exploſions increaſed in loudneſs and light as the glaſs grew colder.

Experiment VI.

A person who was continually electrified from the bar took hold of the blowing-iron, on which was gathered a freſh quantity of melted glaſs. Immediately to this I applied a piece of iron, and drew out from the glaſs a ſlender thread

thread of above four feet in length. During all the time of drawing it out, no signs appeared of there being any electric matter in the person. But soon after (for the thread of glass was presently cooled) the person was strongly electrified.

Experiment VII.

I ordered another piece of melted glass to be gathered, nearly equal in quantity to the former, and having electrified the filings in the vial to the greatest degree, I placed the melted glass (which was better than four inches thick round the end of the blowing-iron) so as to make up a part of the dissipator. (See fig. 21.) Upon compleating the circuit, an explosion ensued, and near the whole quantity of electric matter was dissipated; in like manner as when the circuit is compleated with a bar of iron, or a wire only. But these effects were not produced when the glass became colder; even though the glass was not a quarter of an inch in thickness.

Experiment VIII.

I repeated this last experiment, but did not electrify the filings in the vial so strongly, and instead of compleating the circuit with metal, I did it with my hands, when I felt the usual painful sensation and convulsive shock in my arms and across my breast.

Experiment IX.

I tried the ſame experiments with a large piece of heated amber, inſtead of melted glaſs, and found the effects to be much the ſame as in the foregoing experiments.

Upon the whole of theſe experiments, doth it not ſeem, that, was ſpirit of turpentine, or lintſeed oil, and many other fluids, to become hard and dry ſolids, they then would become ſtrong electrics? M. *Boyle*, found by evaporating about a fourth part of good turpentine, that the remaining body, when cold, hardened into a tranſparent gum, almoſt like amber, which proved electrical: and by mixing two ſuch liquors as *petroleum*, and a ſtrong ſpirit of nitre, and then diſtilling them, he obtained a brittle ſubſtance, as black as jet, which alſo was an electric. He likewiſe found that a glaſs made of the aſhes of antimony, and alſo a glaſs made of lead without any addition, had the ſame electrical properties with other glaſs. The glaſs of lead, he obſerves, might eaſily be brought again to afford malleable lead, which is a non-electric body. See his *Mechanical Production of Electricity*.

By boiling turpentine and water together, which are two non-electrics, an hard tranſparent ſubſtance is produced called Colophony. This will move light bodies like amber upon

friction;

friction; but if it be reduced into a fluid state again by melting, then it becomes a strong non-electric: as appears from its conducting the electric matter to other bodies, in like manner as iron, lead, or any other metal.

PROPOSITION XXXI.

Such solid bodies as are exceedingly elastic, and whose surfaces are smooth, regard being always had to the light which enters their composition, act more strongly and uniformly upon the electric matter, as well as upon light, in refracting and reflecting it, than bodies that have those properties in a less degree, and whose surfaces are not so even.

For a diamond, which is a body highly elastic, is also highly electric, and it reflects and refracts light more copiously than any other body. Glass is not so hard as a diamond, it is therefore probable, that it is less elastic; and we are certain that it is not so highly electric: nor does it reflect and refract light so copiously as a diamond.

Wax, though a body of a different nature from vitreous bodies, yet agrees with those bodies in being an electric, and repelling the electric matter. It is not so strong an electric as glass, though its refractive power exceeds the refractive power of glass considerably; one

reaſon of which may be its want of hardneſs. For glaſs, as well as wax, when brought into a liquid, or ſoft form, become non-electrics: and as they cool and recover a ſolid form, they become again electrics. See propoſition xxix. Another cauſe of the difference between electrical bodies in their effects, may be the different ſmoothneſs of their ſurfaces, for the ſurface of a diamond is much ſmoother than the ſurface of glaſs; as may be gathered from its reflecting and refracting light more copiouſly, becauſe the rougher any ſubſtance is, the leſs regularly will light be reflected from it. If this be true, with reſpect to light, why may it not in ſome degree hold true with reſpect to electric matter?

From the ſame principles we may explain the difference between a diamond and amber: for was amber equally hard with a diamond, it is probable it would be a much ſtronger electric than a diamond; as its refractive power, in proportion to its denſity, is ſuperior to the refractive power of a diamond, in proportion to its denſity.

PROPOSITION XXXII.

Electric matter may be accumulated in electric bodies.

For, when a diamond is rubbed in the dark, it appears luminous, and attracts and repels

light bodies, and these effects continue for some time after the rubbing ceases, which could not be the case, if electric matter was not accumulated within it [a]. How the electric matter is accumulated within the diamond, may be understood from proposition xvi. For by friction the *atmosphærula* of the diamond, and of the rubber, which are in contact with each other, are both rarified, whence the electric matter flowing from the rubber, must pass with ease from it into the diamond. But the *atmosphærula* on the other side of the diamond not being rarified, at least to that degree, the electric matter cannot pass out of the diamond so easily as it passes into the diamond: and therefore may be accumulated.

[a] Let a large diamond be cemented to the end of a cylinder of glass, or wax, eight or ten inches long, and upon a cake of wax let there be placed a cushion which is made of hair and silk. If a person takes that end of the cylinder of glass in his hand, which is farthest from the diamond, and rubs the diamond upon the cushion, the diamond will not appear so luminous, neither will it act so strongly upon light bodies, as when it is rubbed upon a non-electric.

The effect, with respect to the electric matter's acting upon light bodies, is much the same, if, instead of a diamond, amber be made use of after the like manner; and it is probable, was amber equally transparent with a diamond, it would appear equally luminous.

The same effects are observed, though in a lesser degree, upon rubbing glass. The reason why these effects are not so strong, seems to be, that the *atmosphærula* of glass is not strong enough to confine it within the body, but suffers it to pass out more freely than the diamond.

That the accumulation of electric matter in bodies electrified arises from the resistance being less where the electric matter enters than where it passes out, may be farther illustrated from what follows.

Experiment.

If the glass G (fig. 1.) be exhausted of air, and afterwards rubbed with a hand or cushion, the inside of the glass will appear luminous.

The reasoning made use of in the xvith and last propositions, seems to hold equally true here; for the resistance on the outside of the glass, which arises both from its *atmosphærula* and the surrounding air, being greater than on the other side of the glass, when the air is taken away, the electric matter should pass where the resistance is least, and this appears to be the case in the exhausted glass.

If it be supposed otherwise, to wit, that the electric matter accumulated between the pores of the glass, passes out into the air, surrounding the outside thereof as readily, or nearly so, as into

into the exhaufted cavity; in fuch cafe the refiftance given to its exit out of the glafs arifing from the *atmofphærulæ* of the air and glafs, ought not to be greater than in the other cafe. But this feems to be otherwife; for the accumulated electric matter in the pores of the glafs, paffing from thence into the exhaufted cavity of the glafs, is oppofed by the *atmofphærula* of the glafs only: whereas the outfide is oppofed by the *atmofphærula* of air as well as glafs; and air, we have fhewn, actually retards or oppofes the paffage of electric matter, as well as the *atmofphærula*. Therefore fuch a fuppofition cannot be true.

THIS feems to be farther manifefted from the following experiment. For, if during the rubbing of the exhaufted glafs, light bodies be brought near it, fuch as pieces of leaf gold, down, feathers, &c. they will not be acted upon, and moved towards the glafs fo ftrongly, as they otherwife would, was the glafs not exhaufted.

QUERY. Whether this luminous appearance on the infide of the exhaufted glafs is not moft vifible when the air therein is rarified to a certain degree?

PROPOSITION XXXIII.

When a non-electric body, which is not electrified, is made to approach ſo near to one electrified, that the force ariſing from the elaſticity of the electric matter within the body is greater, in that particular part of the body (by its endeavouring to paſs into the body which is not electrified) than the force ariſing from the elaſticity of its *atmoſphærula*, it will paſs off with a ſudden motion, and be condenſed more and more as it approaches the electric body; till at length an exploſion follows.

For as ſoon as the elaſtic force ariſing from the accumulated electric matter is ſufficient to overcome the elaſtic force ariſing from the *atmoſphærula*, by which the electric matter is retained in the body, and the leaſt quantity thereof moves towards the approaching body, the force with which it tends to the latter, increaſes every inſtant, and cauſes a greater condenſed focus of that electric matter, whilſt the force ariſing from the *atmoſphærula* decreaſes; conſequently the electric matter muſt paſs off ſuddenly, and not by degrees: and after coming into the air between the bodies, cauſe an exploſion by virtue of a ſulphureous matter that is carried along with it. See corrol. ii. prop. xvii.

SECTION

SECTION XIII.

PROPOSITION XXXIV.

THE electric matter passes both into and out of bodies which have points, edges, or angular terminations, more readily than it does into, and out of bodies of the same kind which have no points, edges, or angular terminations.

THE truth of this is manifest from several experiments following the vii[th] and xxii[d] propositions.

PROBLEM.

LIGHT bodies moved to a body electrified, may be detained there by apposing fine points or edges to them at a considerable distance: and if blunted or obtuse points or edges of the same kind be apposed at the same distance, those light bodies will be no longer detained, but will recede from the electrified body. And upon apposing fine points or edges again, the light bodies will be forced back again to the electrified body.

EXPERIMENT I.

[a] AT a foot distance (or thereabouts) from the bar B B (fig. 22.) hold a feather, or a piece

[a] Mr. *John Canton* made several curious experiments of the same kind with this.

of

of down D, and when it leaves the hand, or is moving towards the bar, appoſe the point of a needle, which is not electrified, at fifteen inches, or a greater diſtance from the bar; but ſo that the down D may be between the bar B B and the point of the needle P. The down D, in this caſe, will be driven quicker and cloſer to the bar B B than if the needle was not appoſed: and the down may be detained there for any time by continuing to hold the needle in the ſame poſition; notwithſtanding the electric matter moves from the bar B B to the needle P. See obſerv. v. prop. 7.

Experiment II.

Holding the needle at the ſame diſtance as before, turn it, ſo that the eye or head thereof may point towards the bar B B, and the down D, and immediately on doing this the down will be no longer detained at the bar, but will recede or drop from it.

Experiment III.

Take two downy feathers, as nearly equal in ſize and weight as can be had, and place them at ſuch a diſtance from the bar B B, as that the electric matter iſſuing from the bar ſhall be able to move them towards the bar; and let one of thoſe feathers be ſeparated from the other two feet at leaſt. Then when the feathers begin to move towards the bar, let the point

point of a fine needle be appoſed to either of them; immediately on doing this, the feather, to which the needle is appoſed, will be driven to the bar, and detained there: whilſt the other, inſtead of approaching the bar, will recede or fall down, and remain unmoved, while the needle is held in the ſame poſition.

N. B. In theſe three laſt experiments, we ſuppoſe the wheel to be continued turning all the time.

To explain theſe phænomena from the principles we have been endeavouring to eſtabliſh:

Suppose an elaſtic medium to be diffuſſed through any given ſpace, and a cone BBP (fig. 22.) to be formed therein by the motion of particles of the ſame kind propagated from the ſurface of a body BB (ſituated in a part of that ſpace) in ſuch a manner as afterwards to tend to a point P. The action of a fluid thus moving and conſtituting the cone, will cauſe the elaſticity of the particles ſurrounding it to become greater, conſequently the fluid will be denſer on the outſide of the cone than in any part of the cone itſelf. And it will be rarer at the center of the baſe of the cone than in any other part of the cone: and in receding from the baſe to the vertex, its denſity continually increaſes. A light body then placed in the cone,

cannot

cannot pass out of it into the circumambient condensed fluid, but must be forced close to the center of its base; notwithstanding the motion of the fluid is contrary, to wit, from the base to the vertex. Now, why may not the *æther* be the elastic medium diffused in the manner supposed above, and the needle's point be considered as the vertex of such a cone whose base lies at the electrified body BB. The electric matter then will be densest at the point of the needle P, less dense between the needle's point and the bar BB, and rarer still at the bar BB, consequently the down D, or any other such light body, when placed between BB and P, must be forced to the electrified bar BB; detained there, and pressed in a manner close to it, so long as the needle is held in the same position, and the body is continued to be electrified.

Hence may be seen the reason why both the feathers mentioned in the third experiment do not exhibit the same phænomenon.

If an obtuse or broader pointed body (which must now be looked on as the section of a cone) be apposed, as in the second experiment, as the surface is hereby increased, the area of the *atmosphærula* will be larger likewise; and the resistance arising from it will be greater (see prop. ii.) therefore the electric matter

ter will not tend towards it with ſo great a force as in the other caſe, becauſe it cannot diſſipate ſo faſt by this obtuſe point; but muſt paſs off in other places where the reſiſtance is leſs, by propoſition vii. and xvi. Now as all action between bodies is mutual and equal, and only a ſmall quantity of electric matter paſſes towards the obtuſe point, the force ariſing from this ſmall quantity muſt be weak and inſignificant; and the force with which the down will be repelled from it to the electrified body will be ſo too: nor can it poſſibly, as in the other caſe, be forced back towards the electrified body (unleſs the obtuſe point be moved nearer it) for the repelling force ariſing from the electric matter in this caſe will be greater between the feather and the electrified body, than between the feather and the obtuſe point.

WHAT has been ſaid already in regard to pointed bodies, we think, may be ſufficient for explaining the various phænomena producible therefrom: we ſhall only mention two or three experiments more of this kind, which are equally ſurpriſing, and leave the application of them to the reader.

EXPERIMENT.

IF a very fine downy feather F (fig. 23.) with long fibres, be fixed upon the bar B B, and electrified, the fibres will be ſtretched out

in

in many directions, all of them receding from one another. Now if a person ſtands on the floor at the diſtance of two or three feet (nay ſometimes more, when the machine electrifies ſtrongly) holding a needle N, finely pointed, with the point towards the feather F, the fibres thereof will be forced cloſe together (as if they were preſſed) but always moſt on that ſide which is neareſt the needle. If the perſon, inſtead of ſtanding on the ground, ſtands upon wax, the effects will be weakened greatly.

EXPERIMENT.

AGAIN, if the perſon ſtanding either on the floor or on wax, turn the needle, ſo that the head thereof may point towards the feather, the fibres will then recover nearly their firſt form, or poſition, and be ſtretched out again in many directions, without any other change of circumſtances. But if the head of the needle be brought conſiderably nearer the feather, then the ſame phænomenon will inſue as happens from the fine points, though in a weaker degree.

EXPERIMENT.

IF a down feather, of the ſame kind with that made uſe of in the laſt experiment, have a thread four or five inches long faſtened to it, ſo that the thread may hang from the feather as many inches, the feather will be moved to the bar, and be ſuſpended; where it will con-

tinue

tinue whilst the bar is continued to be electrified. But if a person who is electrified with a pair of sciffars in his hand clips the thread off, the feather will immediately fall, or be repelled from the bar.

SECTION XIV.

PROPOSITION XXXV.

LIGHT bodies, such as down, leaf gold, leaf silver, &c. which in the open air are moved or forced to bodies electrified, will not be affected in like manner in *vacuo*, nor when the air is confined: provided the vessel in which the light bodies and the electrified body are put, be set upon an electric body.

EXPERIMENT.

SUPPOSE C (fig. 24.) to represent a glass cylinder, to both ends of which A and B [a] are closely cemented two plates of metal. On the plate B is screwed a stop-cock. Set this cylinder, having first exhausted the air, and dried

[a] *N. B.* The plates A and B should be cemented to the glass, and not laid on with wet leather, unless it be with oil; but even that must be used sparingly, because the moisture may adhere to the sides of the glass, and thereby prevent the experiment succeeding.

the

the glaſs very well upon wax w, ſtanding upon the end A, there being firſt ſome very light body laid within the cylinder at the bottom A, and the in and out ſide of the cylinder being well dried; then let a perſon ſtanding upon an electric, take hold of the moveable wire M, which is ſo contrived as to be puſhed up or down, as occaſion may require, without admitting the air. In ſuch circumſtances, the perſon and wire being both electrified, the leaf gold will not be raiſed from A, even though the wire M be moved extremely near to it. Nor does letting in the air ſeem to make any kind of difference.

N. B. We have not been able to find that cylinders of different lengths, or different diameters, produce different effects from what was obſerved in the laſt experiment. For upon making uſe of a cylinder two inches wide and forty inches long; and another of ten inches wide and fifteen deep, the leaf gold placed at one end, would remain there, though the electrified wire M was moved very near to it in each experiment.

PROPOSITION XXXVI.

Light bodies, ſuch as down, leaf gold, leaf ſilver, &c. when placed in a glaſs veſſel which ſtands upon a non-electric, will be differ-

ently affected by an electrified body, placed likewise in the same vessel in air and in *vacuo*. In air, they will be moved towards the electrified body, and in *vacuo* they will not.

EXPERIMENT I.

INTO a cylinder of glass, eighteen inches long and eight inches in diameter, I put a little leaf gold; and afterwards cemented a plate of metal to each end of the cylinder: one of those plates had a stop-cock fitted to it; and in another part of the same plate there was a collar of leathers, through which was put a wire of a considerable length. But before the plates were cemented, I hung a small ball of metal to that end of the wire which was within the cylinder. Then setting that end, at which the leaf gold was laid, upon the ground; after having exhausted the glass, I electrified the other end, by letting a chain, which hung to the bar, communicate with the brass at the upper end of the glass; whilst at the same time I stood upon wax, and held in my hand the end of the wire which passed through the collar of leathers. Upon moving the ball nearer to, or farther from the leaf gold, as I thought proper, I did not find in any of the trials that the leaf gold ever left the bottom plate: though I was convinced in every trial, from the explosions which were caused sometimes from myself, and at

others from the wire, by the approach of a non-electric body, which was not electrified, as well as from other effects, that there was more than a sufficient quantity of electric matter in the electrified ball to move the leaf gold.

EXPERIMENT II.

HAVING an opportunity of trying the last experiment with a glass of a larger size, and of the shape represented by the 25th figure, it being about fourteen inches deep, and about twelve inches wide in the broadest part, I repeated the experiment; but, instead of cementing the metal plates, I moistened a leather for each plate with a little oil, and instead of removing the glass from the air-pump, as was done in the last experiment, I continued it upon the pump, and caused a chain which was fixed to the bar to communicate with the wire and ball in the glass. Upon turning the wheel, and observing the degree of strength of the electrifying power in the wire, I found the experiment to succeed in the same manner as was mentioned in the last experiment.

EXPERIMENT III.

UPON letting in part of the air, the leaf gold immediately moved from the bottom towards the electrified ball, but not so vigorously as when the whole air was let in: but even in this case the motion of the light body towards the electrified

fied body, did not appear altogether ſo vigorous as in the open air.

The reaſon why the leaf gold was not moved in the firſt and ſecond experiments, ſeems to be that the ſides of the glaſs were more ſtrongly electrified when the air was taken away, than when it was not; for when the ſides of the glaſs are electrified, they may diſturb the force which would otherwiſe cauſe the leaf gold to move towards the electrified ball, and that diſturbance muſt be greater or leſs, as the ſides of the glaſs are more or leſs electrified. For equal and contrary forces always deſtroy one another.

This reaſoning ſeems to be in a great meaſure confirmed from the different effects produced by glaſſes of different diameters.

Experiment IV.

For upon making uſe of a tube of glaſs eighteen inches in length and two in diameter, and another of four feet in length and two inches in diameter, I found that the leaf gold remained at reſt when the air was taken away; and that on letting in part of the air, or indeed the whole quantity, no apparent alteration was made; for the leaf gold continued unmoved in all theſe caſes.

Experiment V.

Upon making use of a cylinder three feet in length and four inches in diameter, the other circumstances being the same, I did not find any difference in the experiment, whether the air was exhausted or not, excepting a very weak trembling motion of the leaf gold, which was observed in both cases.

Experiment VI.

On trying the same experiments with a cylinder of glass eighteen inches long, and five inches wide: the leaf gold appeared to be affected very near alike, whether the air was taken away or not. For when the air was taken away, the leaf gold seemed to shew the like trembling motion as mentioned in the fifth experiment; and when the air was let in, that motion seemed not much increased.: but the leaf gold never left the bottom of the cylinder in either of these cases.

In these last experiments, when the several cylinders were exhausted, I tried whether their outsides were electrified; and if they were, whether letting the air into the cylinders made any difference. I found that their outsides were electrified, and more highly so when the air was taken out of the cylinders than when it was not.

I like-

I LIKEWISE tried whether an exploſion could be produced in *vacuo* with the ſame ſucceſs as in air; and found that when the air was taken away, there was no exploſion.

PROPOSITION XXXVII.

A LIGHT body may be ſuſpended between two bodies, the one electrified, the other not, in ſuch a manner, as that it ſhall not touch either of them: and ſhall always be farther from the electrified body than the body which is not electrified, whether they be inverted or not. And the diſtance from the electrified body will be always greater or leſs, as the two bodies are more or leſs electrified.

EXPERIMENT I.

IF leaf gold, leaf ſilver, or any other light body, G (fig. 26.) be held near a plain of metal P, which is electrified, it will be moved towards the plane: and when G becomes equally electrified, it will recede from P (ſee experim. vii. ſect. iii.) But if another plane of metal P, which is not to be electrified, be held parallel to P, at about ſix or eight inches diſtance, ſo that G may be between them (nay, ſometimes at a much greater diſtance) the light body G will be ſuſpended between the two planes P and p. And if P and G are electrified to a great degree, the diſtance of G from P may be

made greater than when they are electrified to a less degree.

EXPERIMENT II.

IF a person standing on wax, holds the plane p in his hand, the distance at which G will be suspended from P, decreases as the person becomes more and more electrified: this appears from the person's being obliged to move the plane p nearer P, in order to keep the body G suspended. But when the person and the plane p becomes equally electrified with P and G, then G will not be suspended, but remain at rest.

IN order to explain these experiments, let us suppose the electric matter in a body, as it rushes out on the *æther* surrounding it, to form a kind of atmosphere, which is of greater or lesser extent as the body is more or less electrified (see experim. vii. sect. iii.) When therefore two bodies are electrified to a great degree, the diameters of their atmospheres (if they may be so called) and the resistance arising from them will be greater, than when they are electrified to a small degree, and consequently the greater will be the force with which they recede from each other. Now, if two bodies of unequal weights, suppose P and G, be equally electrified, and a third, which is not electrified, suppose p, be apposed, as in the first experiment;

In

In ſuch circumſtances we find that G will be ſuſpended. And it will be nearer the non-electrified body p than the electrified body P: becauſe the reſiſtance ariſing from the *atmoſphærula* of p, is leſs than the reſiſtance ariſing from the electric atmoſphere of P. And this is farther confirmed from obſerving that upon electrifying p equally with P, as in the ſecond experiment, G continues no longer ſuſpended, but falls down by the force of gravity, the forces ariſing from the electric atmoſpheres of P and p, being now equal, and deſtroying each other.

Note, If G be very light, it may be ſuſpended without the aſſiſtance of the plane p, provided ſome other non-electric body be within four or five feet of the plane P, towards which non-electric G will always tend. The reaſon we have given before, ſeems to hold equally true in this caſe; for as the air may be electrified, and G tends towards the non-electric, the reſiſtance ariſing from the *atmoſphærula* of the air and the non-electric muſt be leſs than the reſiſtance ariſing from the electric atmoſphere of P. This is likewiſe confirmed from obſerving, that upon removing the non-electric to a much greater diſtance, G no longer continues ſuſpended.

EXPERIMENT.

If two, three, four, or more pieces of leaf gold, leaf silver, or any other light bodies, be placed between the two planes P and p, as in the first experiment, when P is electrified they will be suspended between the planes, but at a considerable distance from each other. For the atmosphere of electric matter surrounding each piece, repels its neighbour, and prevents them coming together, or approaching nearer to one another, though their several distances from p, are nearly equal.

N. B. In the making of this experiment, when the turning of the wheel, or the supply of electric matter is not equal, sometimes two or more pieces of leaf gold will approach one another, and endeavour to form one continued line or stream of non-electric matter from P to p, by which means the electric matter will flow more readily from P to p; and oftentimes at that instant, most, if not all, of the other suspended bodies drop down and remain at rest.

We have proved, that under certain circumstances, thin electric bodies resist or oppose the entrance of electric matter less than bodies of the same kind that are thicker.

We have likewise shewn, that upon heating electric bodies they are rendered non-electric.

QUERY,

QUERY. May not these different effects observed between thick and thin electrics of the same kind; for instance, thick and thin cakes of wax, arise principally from the different quantities of light contained within different quantities of the same matter?

AND may not the different effects observed in electric bodies, when moistened, heated, or made fluid, from what are observed in the same bodies not affected by moisture or heat, arise from some change in the *atmosphærulæ* of the bodies, or in the texture of the parts of the bodies themselves?

PROPOSITION XXXVIII.

IF a given quantity of electric matter was to pass directly through any number of bodies of the same kind, placed in a right line of a given length, so that their diameters may measure the whole length of the line, the resistance given to its passing through them will be least when their diameters are the greatest, and greatest when their diameters are the least; or in other words, the resistance will be least when it passes through the least number, and greatest when it passes through the greatest number, both measuring the same length.

FOR if the resistance given to the exit or entrance of the electric matter in non-electric bodies, arises only from the *atmosphærulæ* surrounding

rounding them: and if the resistance is the same in bodies of the same kind, whether they are large or small: it is evident the lesser number of bodies the electric matter passes through, the lesser also must be the number of *atmosphærulæ*, and consequently the lesser the resistance. But we have shewn that in bodies of the same kind, whether they are large or small, the resistance arising from their *atmosphærulæ* is the same.

To illustrate this, let A, L (fig. 27.) represent the line given, B, C, two spheres, and a, d, a, v, the *atmosphærulæ* surrounding them. If now a particle of matter be supposed to pass along A L through B and C, it must pass through four *atmosphærulæ* only, to wit, a, d, a, v; whereas there would be many more for it to pass through were there a greater number of bodies of smaller diameters placed in the same line[a].

Now the larger the body is, which a given quantity of electric matter is to be expanded in, the more that quantity will be rarified (see

[a] Since the refractive power of air is continually the same in all parts where the density is given; and as electrical experiments are for the most part made in spaces where the density of the air differs very little, the force which resists the entrance of the electric matter into the particles may be supposed equal in the several particles.

experim.

experim. ix. ſect. iii.) and the more it is rarified the leſs it will oppoſe the entrance of a freſh ſupply of electric matter. Hence we may gather the reaſon, why the electric matter in a body may have a ſtronger tendency to paſs into groſs bodies, ſuch as gold, ſilver, lead, iron, braſs, copper, tin, and all other metallic bodies, moiſt and fluid ſubſtances, and more particularly into the earth itſelf, than into dry air.

THAT air reſiſts the paſſage of the electric matter will be farther illuſtrated from the following experiments.

EXPERIMENT I.

To each end of a hollow cylinder of glaſs G, about eighteen inches long (fig. 28.) and about five inches diameter, let there be fixed with cement two plates of metal B and C: through a hole in one end, ſuppoſe B, in which there is a collar of leathers, a wire w is to paſs, which may be moved higher or lower at pleaſure, in like manner as was directed in the experiment following the xxxivth propoſition. Let there be likewiſe on the outſide of one of the ends a ſtop-cock to ſcrew on to an air-pump, in order to extract the air out of the cylinder. In ſuch circumſtances either end of the cylinder may be electrified. Now upon electrifying either end (the room being dark) when the air is not exhauſted, no light will be ſeen to paſs from the

the wire w to the oppoſite end of the cylinder C, or from C to the wire w; whereas, if the air is exhauſted, and B is electrified, then a ſtream of light appears to paſs between the wire w and the oppoſite end C, repreſenting a cone, whoſe apex is at the end of the wire w at D, and the baſe at C.

EXPERIMENT II.

LET one end of a thin tube of glaſs (fig. 29.) two or three feet in length, and two or three inches in diameter, be hermetically ſealed, for example, at A; and to the other end B, let there be fixed a ſtop-cock, and let a ſtraight wire B C, ſix or eight inches long, be fixed to B, ſo that it may lie in the axis of the tube. Now, if the tube exhauſted of air, be ſuſpended with ſilk lines, and afterwards electrified, upon holding a non-electric body at the end A, a light will iſſue, which will ſeem to paſs from the wire towards A, even though the diſtance be more than two feet, and the *atmoſphærulæ* of the outer and inner ſurface of the glaſs are interpoſed between the wire and the non-electric body without.

SECTION

SECTION XV.

HITHERTO we have been endeavouring to establish certain principles from experiments and observations. And though all of them may not be strictly true, yet we hope that most of them may assist others in their inquiries after truth. What follows is an application of those principles towards explaining the cause of gravitation, and some other phænomena. I am sensible that many may esteem this an extravagant undertaking: but as every attempt to promote useful knowledge is truly laudable; and what I have delivered is proposed only as queries; I hope it will meet with that indulgence and candour, which are the inseparable attendants of distinguished sense and learning.

PROPOSITION XXXIX.

SINCE gravitation is supposed to depend upon the graduation of the density of the *æther*, it follows, that the more that density is increased, the greater will be the force of gravitation.

IF the *æther* be diffused, as Sir *Isaac Newton* supposes, this proposition is self-evident.

PROPO-

PROPOSITION XL.

If *æther* be accumulated within a body, and the *æther* surrounding that body be equally dense, and afterwards passes out from all parts of the body equally, the density, and consequently the pressure of the surrounding *æther* will be increased; and this increase of density will be greater or less, as the quantity passing out is greater or less: and will continue so long as the *æther* continues to pass out of the body.

If we are able to accumulate the *æther*, then this proposition is also self-evident.

PROPOSITION XLI.

If *æther* be accumulated within a body, and the density of the surrounding *æther* be greater on one side of the body than it is on the other, the accumulated *æther* will pass out in the greatest quantity where the density of the surrounding *æther* is least, and in the smallest quantity where the density of the surrounding *æther* is greatest: or in other words, the accumulated *æther* will pass out in the greatest quantity where the resistance is least, and in the smallest quantity where the resistance is greatest: consequently if the *vis inertiæ* of the body be less than the difference of the pressure of the *æther*, or than the resistance on any two sides

sides of the body in any instant, it will be moved towards that side, and in that direction where the pressure upon the body, or the resistance is least.

For, if pieces of leaf gold, sand, powdered glass, rosin, or any other light bodies, A, whether non-electrics or electrics, are electrified, and placed near a large non-electric body B, which is not electrified, they will move towards it with great rapidity. And if any other body, which is something larger, be electrified and suspended in a string, so that it may hang in the same horizontal line with the non-electric, which is not to be electrified, the suspended body will move from its natural point of rest, and tend towards the non-electric body, which is not electrified. The resistance on the side of A, next B must be greater than the resistance on the side of A, which is farthest from B, from the *æther's* being rarer between bodies than without them. But the expansive force in the accumulated *æther* within A is equal in every part, therefore A must move towards B.

PROPOSITION XLII.

If when *æther* is accumulated within a body B, part of it be supposed to pass from it into another body A, in which the *æther* is not accumulated; the body A will begin to move

when

when the difference of the preſſure of the *æther* on any two of its oppoſite ſides becomes greater than its *vis inertiæ:* and it will move towards that ſide where the preſſure, or the reſiſtance is leaſt.

EXPERIMENT.

LET a bar of iron repreſent the body B, and be electrified, upon bringing near to the bar pieces of leaf gold, ſand, powdered glaſs, roſin, or any other light bodies, whether non-electrics, or electrics which are not electrified, they will move towards the bar with great rapidity. And if any other non-electric body, which is not electrified, be ſuſpended in a thread, ſo that it may hang in the ſame horizontal line with the electrified bar, it will move from its natural point of reſt, and tend towards the electrified bar.

FOR B, in this caſe, from its *vis inertiæ* being greater than the difference of the preſſure of the *æther* on its two oppoſite ſides, cannot move towards A. But the accumulated *æther* in B can paſs into A, as there is no accumulation of *æther* in A, and may be there accumulated: and the greater the accumulation is, the greater will be the reſiſtance. This accumulated *æther* in paſſing from A into the *æther* ſurrounding it, muſt cauſe a greater denſity or preſſure upon the remote ſide of the body. A, for example,

at *x* (fig. 30.) than on the nearer ſide into which the *æther* paſſes from B. And from this increaſed preſſure, A muſt of neceſſity approach towards B.

If the *æther* continues to paſs from B into A, and does not paſs out again ſo readily, the accumulated *æther* in A will at length become equal to the accumulated *æther* in B: becauſe A will receive continually the *æther* from B, till the expanſive force of the accumulated *æther* in A becomes equal to the expanſive force of the accumulated *æther* in B. And when that happens, both bodies muſt be equally electrified.

PROPOSITION XLIII.

When the *æther* is denſer between bodies than without them, ſo that the difference of the denſity exceeds the *vis inertiæ* of the bodies, they will recede from one another.

Now, when two bodies, ſuppoſe thoſe mentioned in the third ſection, experiment vii. are equally electrified, the *æther* muſt be denſer between them than on their outſides. For the *æther* cannot paſs from A into B, or from B into A, whilſt the bodies continue equally electrified. And it appears from experiment, that the *æther* does paſs out at their remote ſides, which it could not do if the *æther* was not rarer, con-

sequently the resistance is less on the outside of the bodies than between them; therefore if the *vis inertiæ* of either, or both, be less than the difference of the density of the *æther*, they must of necessity recede from one another.

The truth of the preceding propositions contained in this section, may be confirmed by a great variety of experiments. But as they are all pretty nearly of the same kind with those already mentioned, and as they all seem to be explicable by the same principles, I shall only set down a few of the most material ones.

Experiment I.

Suppose A and B (fig. 31.) to be small equal balls of cork or metal, suspended in lines of silk, fifteen or twenty inches long, and hung at about six or eight inches apart. If one of them, for example, A be electrified, they will both move towards each other, and when the density of the electric matter in one, becomes equal to the density of the electric matter in the other, they will recede from each other.

Experiment II.

If the same balls be suspended with thread instead of silk, and one of them, for example A, be suspended on a non-electrie body which is electrified; whilst the other body B is suspended on a non-electric, which is not to be electrified; they

they will move towards, but never recede from each other, whilst any considerable quantity of electric matter remains.

The difference observed between this and the last experiment, is owing to the line and the body to which B is suspended, which in this case are conductors of the electric matter. For the electric matter passing into B, is conveyed by the thread into other non-electrics, and as fast as B receives it from A: so that there can be but very little if any difference between the density on the inside and on the outside of the bodies.

Experiment III.

If the electric body A be suspended with thread, and the other body with silk, then B will move towards A, and A towards B: and when B becomes equally electrified with A, both will be repelled.

This last experiment is the same in the effect with the first, only that the electrified body is suspended with thread instead of silk.

Experiment IV.

If A be suspended by a silk line upon the bar, and be electrified by means of a wire, which is to be removed as soon as A is electrified: and B be suspended by a thread line on a non-electric body, which is not to be electrified, they will move towards each other. On

their near approach, the greatest part of the accumulated electric matter in A will be dissipated, and in a very short time both A and B will recover their natural points of rest.

For A having at first but a small quantity of accumulated electric matter, and when it loses any part thereof, being incapable of receiving more from the bar on account of the interposition of the silk line, so much electric matter as enters B will immediately pass by the thread into other non-electrics.

Experiment V.

If a large non-electric body be laid upon an electric, and afterwards be electrified, a light body B, placed near, will be first moved towards, and afterwards driven from it.

This last experiment is similar to the first.

Experiment VI.

If A be not electrified, and the light body B placed near it be electrified, it will be moved towards A: and upon its very near approach to A, will cease to be electrified.

According to the before-mentioned law of the *æther*, its density in any body (supposing the density of the *æther* in a body to be inversely, as the density of that body) will be exhibited in the following table. As also the proportion of the pores to the solid parts in the same bodies.

The

THE theorem from which the proportions of the pores to the ſolid parts were got, is the theorem by which Doctor *Robinſon* composed a table of the ſame kind, publiſhed in his *Appendix* to his *Diſſertation on the æther*.

$\frac{41.244-\Delta}{\Delta}$ the meaſure of the pores to the ſolid parts was thus found. Let the pores to the ſolid parts, or the ſpace poſſeſſed by the pores of a body to the ſpace poſſeſſed by its ſolid parts, be as P. to 1. Then $P+1$ will expreſs the whole ſpace poſſeſſed by the body, or the magnitude of the body. The quantity of matter in the body is meaſured by its magnitude and denſity taken together, that is, 1 is as $P+1 \times \Delta = P\Delta \times \Delta$, whence Δ is as $\frac{1}{P+1}$. The ſpecific gravity of fine gold by the table is 19.64. The ſpecific gravity of water 1; and Sir *Iſaac Newton*, from ſome obſervations, thinks gold has more pores than ſolid parts. Doctor *Robinſon* ſuppoſes the pores to the ſolid parts to be as 11 to 10, or as 1.1 to 1. In gold, therefore, Δ is 19.64 and $\frac{1}{P+1}$ is $\frac{1}{2.1}$, and to find the pores to the parts in another body, uſe this analogy $19.64 : \frac{1}{2.1} :: \Delta : \frac{1}{P+1}$. Now $\frac{19.64}{P+1} = \frac{\Delta}{2.1}$ and $41.244 = P\Delta + \Delta$; and $P = \frac{41.244-\Delta}{\Delta}$, the quantity of the ſolid parts being 1.

	Specific density of bodies, according to Mr. *Boyle* and others.	Density of the *æther.*	Pores to the solid parts
Fine gold	19.640	0.0509	1.100
Standard gold	18.888	0.0529	1.118
Quickfilver	14.000	0.0714	1.946
Lead	11.325	0.0883	2.641
Fine filver	11.091	0.0901	2.718
Standard filver	10.535	0.0949	2.916
Bifmuth	9.700	0.1031	3.252
Copper	9.000	0.1111	3.582
Caft brafs	8.500	0.1176	3.852
Steel	7.852	0.1273	4.252
Iron	7.643	0.1308	4.396
Tin	7.320	0.1366	4.634
Glafs of antimony	5.280	0.1893	6.807
A pfeudo-topaz	4.270	0.2342	8.659
A diamond	3.400	0.2941	11.130
Mr. *Ellicott* found the mean fp. grav. of four Brazil diamonds feparately; two of them rough coats, and two bright coats to be	3.513	0.2846	10.741
And ten Eaft-India diamonds of different colours to be	3.519	0.2841	10.720
The mean of both	3.517	0.2843	10.727
Clear cryftal glafs	3.150	0.3174	12.093
Ifland cryftal	2.720	0.3676	14.163
Fine marble	2.700	0.3703	14.275
Rock cryftal	2.650	0.3773	14.563
Common green glafs	2.620	0.3816	14.742
Stone of mean gravity	2.500	0.4000	15.496
Sal. gem	2.143	04.666	18.246
Brick	2.000	0.5000	19.622

Nitre

	Specific density of bodies, according to Mr. *Boyle* and others.	Density of the *æther*.	Pores to the solid parts.
Nitre	1.900	0.5263	20.707
Alabaster	1.875	0.5339	20.996
Dry ivory	1.825	0.5478	21.599
Brimstone	1.800	0.5555	21.913
Dantzick vitriol	1.715	0.5831	23.049
Alum	1.714	0.5834	23.050
Borax	1.714	0.5834	23.050
Calculus humanus	1.700	0.5882	23.261
Oil of vitriol	1.700	0.5882	23.261
Oil of tartar	1.550	0.6451	25.609
Bezoar	1.500	0.6666	26.496
Honey	1.450	0.6896	27.444
Gum arabic	1.375	0.7272	28.995
Spirit of Nitre	1.315	0.7604	30.364
Aquafortis	1.300	0.7692	30.726
Serum of human blood	1.190	0.8403	33.658
Pitch	1.150	0.8695	34.864
Spirit of salt	1.130	0.8849	35.499
Spirit of Urine	1.120	0.8928	35.825
Human blood	1.040	0.9615	38.657
Amber	1.040	0.9615	38.657
Milk	1.030	0.9708	39.042
Urine	1.030	0.9708	39.042
Dry box-wood	1.030	0.9708	39.042
Sea Water	1.030	0.9708	39.042
Common water { freezing point = 0 boiling point = 100 $\frac{17 \text{ to } 18}{100}$ warm }	1.000	1.0000	40.244
Camphire	0.996	1.0041	40.409
Bees wax	0.955	1.0471	42.187
Linseed oil	0.932	1.0729	43.257
Dry oak	0.925	1.0810	43.588

	Specific density of bodies, according to Mr. *Boyle* and others	Density of the *æther*.	Pores to the solid parts.
Oil olive	0.913	1.0953	44.176
Spirit of turpentine	0.874	1.1441	46.189
Rectified sp. of wine	0.866	1.1547	46.626
Dry ash	0.800	1.2500	50.555
Dry maple	0.755	1.3245	53.628
Dry elm	0.600	1.6666	67.704
Dry Fir	0.550	1.8181	73.981
Cork	0.240	4.1666	170.850
Air	0.00125	800.0000	32994.200

It appears by this table, that the density of *æther* in gold is .0509, in cork 4.1666, in air 800.0000; so that the density of *æther* in cork is above eighty times greater than in gold, and in air, above one hundred and ninety times greater than in cork; consequently the density of *æther* in air is above 15700 times greater than in gold. Hence the density of *æther*, in all probability, is much greater in air, than it is in grosser bodies when they are electrified: that is, when the electric matter is accumulated in them. Whence it seems, that in such bodies the force arising from the increase of density is so very weak, as only to impel light bodies, and those at very small distances; which distances vary as the machine electrifies more or less strongly.

Vision,

Vision, according to Sir *Isaac Newton*, is performed chiefly by the vibrations of the *æther*, excited in the bottom of the eye by the rays of light, and propagated through the solid, pellucid, and uniform capillamenta of the optic nerves into the place of sensation. The several sorts of rays make vibrations of several bignesses, which, according to their bignesses, excite sensations of several colours; the most refrangible rays excite the shortest vibrations, for making a sensation of deep violet. The least refrangible the largest for making a sensation of deep red. And the several intermediate sorts of rays, vibrations of several intermediate bignesses to make sensations of the several intermediate colours,

Query. May not this account be farther illustrated from the preceding principles? as thus—

If the rays of light be bodies of different sizes, the least of which make violet and the biggest red [a]: then the largest rays striking upon

[a] Nothing more is requisite for producing all the variety of colours and degrees of refrangibility, than that the rays of light be bodies of different sizes, the least of which may make violet the weakest and darkest of the colours, and be more easily diverted by refracting surfaces from the right course; and the rest as they are bigger and bigger, may make the stronger and more lucid colours, blue, green, yellow and red, and be more and more difficultly diverted. *Newt.*

upon the *atmosphærula* of the *retina* at the bottom of the eye, will act upon a greater portion of that *atmosphærula*, than the rays of light that are smaller. But the more parts of the *atmosphærula* are acted upon by a ray of light, the stronger must be the effect; or in other words, the greater must be the vibrations. Thus it is, the largest rays of light cause the sensation of red, which is the most vivid; and the smallest the sensation of violet, which is the most faint and languid of all colours.

QUERY, As to elasticity, are not all the *phænomena* thereof deducible from the preceding principles, whether bodies rebound or recede from one another by percussion, or when they are forcibly bent, from their own spring they recover their original form and figure? For a fluid, whose particles recede from one another, with a force reciprocally proportional to the distance of their centers, will have its density proportional to its compression (*Newt. Princip. prop.* xxiii. *book* ii.) when the *æther* is condensed, its elastic force will be increased in the same manner as we find in air, when compressed or condensed. Therefore when the parts of a body are brought nearer each other by any force, such as bending or the like, the *æther* within, and the *atmosphærula* without the body, will be condensed at the same time,

time, and by virtue of the condensation (such force ceasing to act) they will be again made to recede from one another, and recover their former figure.

Query, May not cohesion, which is caused by a much greater force than that of gravity, arise from the mutual action of the light, contained within bodies, and of the *atmosphærulæ* surrounding them, the pressure of which *atmosphærulæ* alone may be sufficient to make the particles, when very near or in contact, cohere with a great force, after the manner we have particularly described in pag. If this is the case, the force of cohesion then must be proportional to the *atmosphærulæ* of the particles. Now the *atmosphærulæ* seem to be nearly, as the density of the bodies (See Propositions xx and xxi.) therefore the forces with which the parts of bodies cohere, are nearly proportional to their densities.

" Hence the densest particles cohere with " the greatest force, and as they lessen in den- " sity, so they do in the strength of their co- " hesion. This force is of the same nature " with that of fermentation, for the nature of " the particles principally concerned in caus- " ing both cohesion and fermentation, are of " the acid, unctuous, and sulphuruous kind.

CON-

CONCLUSION.

THERE have been ſeveral hypotheſes formed, in order to explain the cauſe of electricity; ſome have ſuppoſed that the electric matter is lodged within bodies, and ſuch only as are reſinous and vitreous; that it lies there in a quieſcent ſtate, but ready to fly off as ſoon as friction has ſufficiently agitated the parts, and dilated the pores: and laſtly, that the quantity of electric matter contained in ſuch electric bodies, reſiſts and oppoſes the entrance of the like kind of matter when it is conducted to them from other bodies. Others are of opinion that the electric matter is ſupplied from the air, and that friction ſerves only to collect it: while a third ſet of gentlemen would have it to be the ſame with *Boerhaave's* elementary fire. Theſe different opinions ſeem neither to be grounded upon reaſon, nor ſupported by experiments.

THAT the firſt two opinions are erroneous, will admit of no diſpute; for was the electric matter produced by friction, electric bodies could never by heat become non-electrics, it being the property of heat to rarify all bodies, even the moſt denſe. Was it wholly ſupplied by the air, bodies would at all times be equally electri-

electrified, whether the machine stood on the earth, or was placed on electrics.

As to the last, I shall refer the favourers of that opinion to Doctor *Boerhaave's* treatise on fire; where they may be convinced, that the notions he entertained of that element, are very different from what is here advanced concerning electricity [a].

[a] To shew that this elementary fire differs from this electric matter, I shall set down some experiments and observations, which were communicated to me by Mr. *Smeaton*, the gentleman whom I have had frequent occasion to mention in this Treatise.

EXPERIMENT.

Upon heating the middle of a large bar of iron to a glowing heat, and then electrifying it, the electrical phænomena, to wit, the power of moving light bodies, and the explosion appeared to be much the same from the parts which were heated, and those which were cooler: so that the electric matter passed through the fire without any visible alteration.

OBSERVATION I.

Now as the supposed elementary fire filled the middle part of the iron bar, and was in some measure fixed therein, there is great reason to believe it would have obstructed the passage of a fluid of the same kind, absorbed it, dissipated it, rarefied it, rendered it more or less elastic, or at least have made some alteration in it, because we always find that two neighbouring vortices of electric matter have a visible effect upon each other, so also, two magnets assist, or obstruct each other according to the situation of their poles.

OBSERVATION II.

When a body is heated, the elementary fire is not in equilibrio in every part of that body; for a body may be very hot

BUT

But as it is unreasonable to destroy the hypotheses of others, without establishing some principles in their stead; I have therefore endeavoured to show, That by friction a very subtile elastic fluid is accumulated or collected — which is capable of being diffused through some bodies, and not through others — the former are distinguished by the name of Non-electrics, the latter by Electrics — That this fluid may be accumulated more or less in non electric bodies — That when it is accumulated, it will expand and dissipate itself, and in the dissipation exhibit, various phænomena, according to the circumstances attending the experiment — That the explosion and the power of moving light bodies, is not as the quantity, but the density of this fluid — and that it is propagated along dense bodies with an exceeding great velocity

in one part, and less hot in another at the same time: whereas every body which is electrified, appears to be equally electrified in every part, and that whether it is equally hot or not.

Experiment.

The flame of a candle may be electrified.

Observation.

This is a farther confirmation, that elementary fire may be electrified.

To this I shall add, that with respect to the explosion, it may probably be owing to very volatile sulphureous parts, thrown off from bodies by the violent motion of the electric matter, which volatile sulphureous parts, mixing with the acid in the air, kindle into flame.

—That

—That this fluid, when it is accumulated in a body, will paſs into thoſe bodies which are neareſt, and give the leaſt reſiſtance—That it is ſupplied from adjacent bodies and the earth itſelf—That the original quantity of this fluid in a non-electric body, may be leſſened or increaſed—That when bodies receive a greater quantity of this fluid, than originally belonged to them; non-electrics that are contiguous, and the earth itſelf, muſt loſe ſome part of the quantity of this fluid, which they originally had—That in certain circumſtances, neither the attenuation nor accumulation of this fluid in a body, can by any methods, hitherto known, be made to exceed a certain degree—That the accumulation of this fluid, in ſome circumſtances, is in the direct proportion, and in other circumſtances, in the reciprocal proportion to the reſiſtance it meets with, as it tends to diſſipate—That nearly the ſame effects are produced by the attenuation, as by the accumulation of this fluid—That upon an exploſion part of the accumulated fluid may be forced through mediums, which reſiſt differently, and that, by the reaction of the particles of the fluid—That on cauſing an exploſion with the vial, the whole quantity of accumulated electric matter that is diſſipated, does not paſs off at that part of the body where the exploſion

plosion is made, but from all parts of the surface, even though it be covered with a thin electric—That the accumulated electric matter is not totally dissipated by repeated explosions—That when the electric matter is accumulated in the vial, the loudness of the explosion, and quantity of electric matter dissipated on compleating the circuit, seem proportional to the points of non-electric contact with the out, and in side of the vial—That when the electric matter is accumulated in the vial, the greatest effects are produced by compleating the circuit. How it comes to pass, that the greatest part of the accumulated electric matter is dissipated by one explosion, I have not taken upon me absolutely to determine; but in order to assist others, who may pursue these inquiries farther, I have set down several experiments of different kinds, and from them proposed a query, concerning the manner in which it seems to be effected; and likewise, concerning the manner in which that painful shock or convulsion of the nerves and muscles, which is generally felt by animals, may be caused—That this strange effect seems proportional to the magnitude of the explosion—That we cannot determine, from the appearance of the divergency of the electric matter which body it issues from; because the electric matter both in passing out of a body, and

and passing into it, has the same appearance— That if a person compleats the circuit, the greatest painful shock will be always felt in those parts, which lie in the shortest line that can be drawn through the person, from the covering of the vial to the wire—That non-electric bodies, placed at small distances without the circuit, will be affected in the same manner, but in a less degree, as if part of the electric matter had passed into them—That an explosion never happens, but when the issuing electric matter is very much condensed— That the greatest explosion is from polished surfaces—That the explosion is greater, the larger the surfaces are, to a limited degree, and—That dense bodies, in their natural state, are capable of receiving a greater quantity of electric matter, than bodies that are rare.

In the second part, we have given a short account of the *æther*, Sir *Isaac Newton* has treated of; then compared it with the properties of the electric matter, and shewn, that they strongly resemble each other—We have therefore considered the electric matter as *æther*, joined with grosser particles, propelled from bodies by the force and vigour of its action— That according to the law of the *æther*, when a body is made rarer, the *æther* in that body must grow denser, and *vice versa*—That friction

tion will cauſe bodies to rarify, as well as the heat of the ſun or any other heat—and That thoſe rarified bodies will contract and grow denſer, on diſcontinuing the friction, or on removing their rarified parts from the friction—That as bodies grow rarer by heat, *æther* flows into them from other bodies—and as they grow denſer by cold, *æther* flows out of them into other bodies—That when two bodies are rubbed againſt each other, the *æther* will flow in a greater quantity into the rarified parts of the bodies, than into thoſe parts of the ſame bodies which are not rarified—And upon the parts of the bodies growing denſer, the *æther* muſt paſs out of theſe bodies, where it meets with the leaſt reſiſtance—That this flowing of the *æther*, which produces all the electrical effects, can only be cauſed by friction—That the flowing of the *æther* muſt gradually leſſen on diſcontinuing the friction—and that the electric effects from the glaſs muſt grow weaker, as it cools and recovers its original ſtate—That it is in ſome degree neceſſary for the cylinder to be turned always one way—That equal effects can never be produced in the bar from the cuſhion and glaſs, by the application of heat without friction—That two thick electrics, rubbed againſt each other, can never produce ſo ſtrong electrical effects, as when an electric and

and a non-electric are rubbed againſt each other —That ſetting the machine on non-electric bodies, moiſtening the leather of the cuſhion and all other circumſtances, to keep an open communication with the cuſhion, are abſolutely neceſſary for producing the greateſt flux of the *æther*—That in order to ſee how far the *æther* is capable of being accumulated in a non-electric body, it is abſolutely neceſſary to ſuſpend, or ſet the non-electric upon ſome electric, which obſtructs or reſiſts the entrance of the *æther*, more than non-electric bodies do —and that the electric bodies ſhould be always dry and free from dirt—That when the *æther* is put into ſuch a motion within a body, as is deſcribed in prop. xvi. it will throw off, by the violence of its action, ſulphur, and other matter lodged on the ſurface, or within the pores, where it is leſs intimately combined with, and united to the parts of, that body— That this ſulphurous matter, when it is thrown off in any conſiderable quantity, ferments with the nitrous acid floating in the air, which fermentation is probably the cauſe of the ſudden blaſt, or violent exploſion obſerved in ſome of the electrical experiments—That *æther* is more ſubtile than light—That denſe bodies have more light in their compoſition than bodies that are rare, unctuous and ſulphurous ones except-

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ed—That unctuous and sulphurous bodies have more light in their composition, than other bodies of the same density—That the power in bodies to refract, reflect, and inflect the rays of light, is nearly proportional to the quantity of light contained in them—That the inflective, refractive, or reflective power of a body extends itself but to a very small distance from the body—That this power seems to be caused by the mutual action of the light in bodies, and the *æther* at their surfaces—That it is of a very great density, and extends to a very small distance from the surface of a body—That the rays of light seem to be reflected regularly by virtue of this medium—That this medium, which we have called the refractive, reflective, or inflective medium, or, in one word, by *atmosphærula*, prevents the electric matter, when accumulated within a body, from issuing so fast as it otherwise would, if there was no *atmosphærula* surrounding that body—That the electric matter, when it issues suddenly through a dense *atmosphærula*, produces a greater effect than when it issues through a rare one—That in two or more circuits made at the same time, with the same vial, but with different bodies, the electric matter will pass only in that circuit, where there are the fewest *atmosphærulæ*; or, in other words, where the resist-

resistance is least—That this resistance may be lessened, as in the chain, by bringing the links into closer contact with each other—That the particles of air have probably *atmosphærulæ* similar to the same kind of bodies, which are grosser and larger—That a sufficient number of them, with such *atmosphærulæ* placed in a medium, such as the *æther*, may constitute an elastic fluid, resembling the atmosphere of the earth—That if any non-electric matter be put into a glass, whose *atmosphærula* is very great, and be afterwards electrified, the resistance the electric matter will meet with in passing out on compleating the circuit, seems to be as the thickness of the glass, the quantity of non-electric contact with the glass, and the sum of the several *atmosphærulæ*; to wit, of the dissipator, the glass vessel, and the matter contained within it—That from the different density of the *atmosphærulæ* surrounding bodies, it principally is, that some are electric, and others non-electric, regard being always had to the texture of the bodies; those bodies which have the densest *atmosphærulæ*, supposing them not fluid, moist, or soft, are called electrics, and those which have the rarest *atmosphærulæ*, non-electrics—That any fluid may be electrified, though the *atmosphærulæ* of many fluids are much denser than that of common glass—

 That

—That electric bodies may be rendered non-electrics by heat, glaſs and amber not excepted—That hardneſs ſeems to be a neceſſary property for making bodies electric—That electric matter may be accumulated even in electric bodies—And that it will always paſs away where the reſiſtance to its exit or entrance is the leaſt—That the electric matter paſſes off with a ſudden motion, when its denſity in any particular part of a body exceeds the denſity of the *atmoſphærula*—That the electric matter paſſes both into, and out of bodies, which have points and edges, more readily, than it does into and out of bodies of the ſame kind, which have no points or edges; and from thoſe properties, we have endeavoured to explain ſeveral curious *phænomena*, in relation to pointed and edged bodies.

In the xiv Sect. we have ſhewn the effects of electric matter upon light bodies, in confined air, and *in vacuo*, as well as in the open air—That the difference between thick and thin electrics of the ſame kind, and the alteration made in their effects by heating, may ariſe from a change in their *atmoſphærulæ*, or in the texture of the parts of the bodies themſelves—That if a given quantity of electric matter paſſes directly through any number of bodies of the ſame kind, placed in a right line of

of a given length, the resistance given to its passing through them will be least, when it passes through the least number, and greatest when it passes through the greatest number — That the larger the body is, which a given quantity of electric matter is expanded in, the more that quantity will be rarified, and the more it is rarified, the less the resistance — From thence I gathered the reason, why the electric matter has a stronger tendency to pass into gross bodies; such as metals, fluids, &c. and the earth itself, than into dry air.

In Sect. xv. which is the last, I have endeavoured to explain the nature of the force, by which light bodies are moved in electrical experiments, and attempted to shew, that it is the same force with that which causes gravitation; which force can be no other, than a fluid exceedingly more subtile and elastic, than air, at the surface of the earth.

What I have said on these matters, is intended chiefly as hints, to excite others to make further researches. That many and useful discoveries will, one day or other, result from the doctrine here advanced, how crude and indigested soever it may now seem, no doubt, I think, is to be made. Abler hands may extend these inquiries farther, and probably complete what I have begun. I should not be sur-

prized, if the nature of muſcular motion, vegetation, and even magnetiſm itſelf, ſhould be hereafter explained upon the ſame principles.

However this may be, what I have advanced ſeems to have the advantage of the ſeveral hypotheſes hitherto framed for explaining the nature of electricity, as it is the moſt univerſal and conſiſtent with itſelf; at the ſame time, that in the moſt plain and ſimple manner it accounts for the other phænomena in nature, as well as thoſe in electricity.

If the exiſtence of an *æther* be admitted, we may reaſon by analogy concerning other parts of this planetary ſyſtem. Heat is obſerved to decreaſe in receding from the ſun, and this decreaſe is demonſtrated, to be as the ſquares of their diſtances. Was our earth then removed three times farther than it is from that luminary, the effects of heat would be nine times leſs; was it placed three times nearer, it would be nine times greater than in our preſent ſituation; in the former caſe, our water would freeze and become ſolid; in the latter it would be even hotter than boiling water, and be more eaſily evaporated. If therefore there are any fluids in the reſt of the planets, which are in our ſyſtem, their parts muſt be exceedingly rare in thoſe fartheſt from, and ex-

ceeding denſe in thoſe which are neareſt to the ſun; for otherwiſe they could never be preſerved in a ſtate of fluidity by degrees of heat, which are ſo very different [a].

LASTLY, as matter is in itſelf inert, the *æther* muſt of neceſſity receive its activity from an *infinitely wiſe*, and *powerful ſpirit.* This *æther*, from its being ſo general a material cauſe, may probably be the great inſtrument, by which the Almighty directs, governs, and ſupports the univerſe.

[a] Prop. viii. Theorema viii. Cor. 4. *Newt.* Princip. Denſiores igitur ſunt planetæ qui ſunt minores, cæteris paribus, ſic enim vis gravitatis in eorum ſuperficiebus ad æqualitatem magis accedit. Sed & denſiores ſunt planetæ, cæteris paribus, qui ſunt Soli propiores; ut Jupiter Saturno, & Terra Jove. In diverſis utique diſtantiis a ſole collocandi erant planetæ ut quilibet pro gradu denſitatis calore Solis majore vel minore frueretur. Aqua noſtra, ſi Terra locaretur in orbe Saturni, rigeſcerit, ſi in orbe Mercurii in vapores ſtatim abiret. Nam lux Solis, cui calor proportionalis eſt, ſeptulo denſior eſt in orbe Mercurii quam apud nos: & thermometro expertus ſum quod ſeptulo Solis æſtivi calore aqua ebullit. Dubium vero non eſt quin materia Mercurii ad calorem accommodetur; & propterea denſior ſit hac noſtra; cum materia omnis denſior ad operationes naturales obeundas majorem calorem requirat.

EXPE-

EXPERIMENTS
UPON
HUMAN BODIES.

IN the month of *May* 1748, I had an opportunity of trying the effects of electricity upon a woman in *London*, who had been deaf many years; ſhe was born in the iſland of *Nevis* in the *Weſt-Indies*, and was about 28 years of age. Her name is *Mary Smargins*.

SEVENTEEN years ago, ſhe became ſo deaf as not to hear any one, unleſs they were very near, and ſpoke loud to her. This deafneſs proceeded firſt, as ſhe believes, from a cold, and was never obſerved to be better at intervals. She always heard the leaſt with the left ear; and when at any time the right ear was laid upon a pillow, or ſtopped, ſhe could diſtinguiſh loud ſounds but very faintly.

I WAS the more induced to make a trial of the electrical effects in this caſe, not only from what I was informed had been done at *Paris*, in caſes of the like nature, but alſo from what Mrs. *Smargins* herſelf told me. That a few days before, upon her being electrified with other perſons in my apartments by the vial, ſhe felt a very unuſual warmth acroſs the ſtomach and

and in each arm, which continued for some time: that on the next day, she had observed a running at her nose, which she attributed to her having been electrified, and which she imagined was of some little service to her. For these reasons, and from an opinion, that the cause of this deafness might proceed from some obstruction in the auditory nerves, which might probably be removed by the violent effects of this subtile electric matter; I proposed to her, the giving the electrical shock, with the vial, across her head.

On *Saturday* the 28th of *May*, I made the first experiment in the following manner.

The covered vial being electrified by two turns of the wheel only, I applied the end of a thick wire, which was fastened to the covering of the vial, to the left temple, just above the ear; then I brought the end of that wire, which was in the vial, towards the opposite part of her head, and there ensued a small explosion. She was much surprized, and perceived a small warmth in her head, but chiefly across it, from ear to ear. I repeated the experiment four times, and made the electrical shock stronger each trial. The warmth excited by the shock increased in each experiment, and though I caused the experiment to be made at each ear alternately, she always found

found the warmth to be greateſt in that ear ſhe heard the leaſt with. At laſt ſhe complained of ſmall twitchings in her ears and acroſs her head, but moſtly in that ear ſhe heard the leaſt with. When theſe experiments were made ſhe did not perceive that any other part of her body was affected by the ſhock. All this day the warmth increaſed, and at intervals ſhe felt twichings in her ears. Her hearing ſhe imagined was ſomething better, ſo did the people with whom ſhe lodged. She was adviſed to keep her head warm. I was informed that in the evening, ſhe waſhed her head in cold water. The next morning early, which was *Sunday*, I repeated the experiments again in the ſame manner, and nearly with the ſame ſtrength. At this time ſhe complained of her arms and body being affected by the ſhock, and ſaid that I had made it much ſtronger than the day before. The warmth ſeemed now quite round each ear, but ſtill greater round that with which ſhe heard the leaſt; the twitchings were alſo more violent. Theſe effects continued all the day. There were ſeveral ſigns this day of her hearing better. For in her lodgings ſhe heard the bells ring, which ſhe had never done before; and the gentlewoman with whom ſhe lodged, obſerved, that ſhe could underſtand what was ſaid to her, though ſpoken

ſpoken in a moderate tone of voice. After theſe experiments, notwithſtanding ſhe was adviſed to take particular care of catching cold, ſhe ſat at night in the window above an hour with the ſaſh open, and her cap pinned up. This evening the warmth left her, and was ſucceeded by a great coldneſs in her head, and a chillineſs all over her body.

The next morning, which was *Monday*, ſhe was extremely ill, with pains all over her. I did not care to try any more experiments whilſt ſhe continued in this diſorder.

On *Tueſday* ſhe was much better, the coldneſs abated, and ſhe felt again round each ear the ſame kind of warmth which ſhe had before obſerved.—This day ſhe mentioned ſeveral circumſtances, which ſhewed her hearing was better, particularly the following ones. She could diſtinguiſh the cries in the ſtreets, and the barking of dogs; and could hear people in the houſe with her going up and down ſtairs, though ſhe herſelf ſat in the uppermoſt room of the houſe.

On *Wedneſday* ſhe was ſomething better in all reſpects, and the noiſe and continual beating in her head, which ſhe had had from the firſt of this misfortune, began now to abate conſiderably. In the evening a very violent ſhooting (as ſhe expreſſed it) went acroſs her head,

head, from the left to the right ear. This day I did not repeat the experiments, but on the day following, which was *Thurſday*, I did. Some minutes after making them, ſhe had occaſion to blow her noſe, when there iſſued corrupted matter with a ſmall quantity of clotted blood. All this morning ſhe felt in her head a glowing warmth, greater than had ever been before. This day, as ſhe was reſting her head upon a pillow, ſhe heard the cries in the ſtreet, notwithſtanding that ear with which ſhe always heard the moſt, was cloſe to the pillow, and was ſo ſurprized and rejoiced, that ſhe got up immediately, to acquaint the gentlewoman of the houſe with it. At noon ſhe heard a perſon at the bottom of the ſtairs calling her down to dinner, though the door of the chamber in which ſhe ſat, was at that time ſhut. Several times that day, I ſpoke to her in a lower tone of voice, than is uſual in converſation, and ſhe gave me direct anſwers to the queſtions I aſked her. She ſaid the noiſe and beating in her head was then almoſt intirely gone.

This day ſhe could hear the opening and ſhutting of the ſtreet door. In the evening Dr. *Bevis* (whoſe name I have mentioned in the preceding Treatiſe) called upon me, as alſo did two other gentlemen, when I related to them this affair, and at the ſame time, deſired they

the would ſtep with me to her, and aſk ſuch queſtions as they ſhould think proper. Upon my ſpeaking to her in a very moderate tone, to my great ſurprize, ſhe deſired I would not talk ſo loud: and what is very remarkable, ſhe had at this time cotton in both her ears, two caps pinned cloſe about them, and a velvet hood on, to keep her warm. As I was obliged to leave town the next morning, I told her, that in my abſence Dr. *Bevis* would be ſo kind to repeat the experiments, if ſhe thought it neceſſary — This ſhe declined, ſaying, that ſhe could not find there was any occaſion; for that ſhe heard very diſtinctly, and her head was very eaſy.

I FORGOT to mention one circumſtance, which was this; ſhe had a great cold, and her eyes were much inflamed at the time I began to make theſe experiments. The inflammation decreaſed after the firſt experiments on *Saturday*, and it was intirely removed after the ſecond experiments on *Sunday*. The diſappearing of which inflammation, ſhe ſolely attributed to the electrical effects. From that time to this, I have not been in *London*, but have had ſeveral letters from my friends, giving an account, that ſhe continues to hear very well.

I HAVE tried theſe experiments upon ſix other perſons, whoſe complaints were deafneſs,

but

but without any ſucceſs. Three of them indeed fancied themſelves better for a few days. One of the others, inſtead of receiving any benefit, complained of a violent pain in his head, and a dimneſs in his eyes; which he ſaid continued for ten or twelve days after the experiments were made.

A GENTLEMAN near ſeventy years of age, was deſirous to feel the ſhock, occaſioned by approaching the vial. I was afraid of electrifying the vial too ſtrongly at the firſt trial; but upon his declaring he ſcarcely felt any pain, I electrified it much ſtronger the ſecond time, and afterwards as ſtrongly as I could; nevertheleſs he was not affected, as is uſual, in the arm and acroſs the breaſt, but only in his wriſts.

IN *Auguſt* 1748, I had occaſion to try ſome experiments, in order to obſerve the different effects produced by a perſon's compleating the circuit with the vial, in different manners; the experiments were of the ſame kind, with thoſe mentioned in the ix^th^ propoſition. I made uſe of my own ſervant, who was about 25 years of age. After the firſt and ſecond experiments, he complained of his ſpirits being depreſſed, and of being a little ſick. Upon making the fourth experiment, he became very warm, and the veins of his hands and face ſwelled to a

great degree. The pulſe beat more than ordinarily quick, and he complained of a violent oppreſſion at his heart (as he called it) which continued along with the other ſymptoms near four hours. Upon uncovering his breaſt, it appeared to be much inflamed. He ſaid that his head ached violently, and that he felt a pricking pain in his eyes and at his heart; and a pain in all his joints. When the veins began to ſwell, he complained of a ſenſation which he compared to that ariſing from ſtrangling, or a ſtock tying too tight about the neck. Six hours after the making of the experiments moſt of theſe complaints left him. The pain in his joints continued till the next day, at which time he complained of weakneſs, and was very apprehenſive of catching cold. On the third day he was quite recovered.

THE ſhocks he received were trifling compared with thoſe which are commonly received by moſt perſons when they join hands to compleat the circuit for amuſement. His being affected more than ordinary might be owing to his conſtitution; for he was conſumptive, and had been ſo for a long time before the making of theſe experiments.

WHEN the experiment with the vial was firſt made by *Muſchenbroeck*, ſoon after I diſcovered a method of increaſing its effects, and

was then able to indure the moſt violent ſhocks along my arms and acroſs the breaſt: but upon repeating thoſe ſhocks often for ſeveral weeks together, I at laſt was weakened ſo much that a very ſmall quantity of electric matter in the vial would ſhock me to a great degree, and cauſe an uncommon pain. So that I was obliged to deſiſt from trying any more. Whether it had any effect upon my health or not, I cannot ſay; but even to this day I am affected nearly in the ſame way by the electrical ſhock.

In order to ſhew how ſtrongly my arms were convulſed, after I had been weakened by frequent repetitions of theſe experiments, I ſhall mention one experiment which the following accident gave riſe to. I undeſignedly touched the wire in the vial when it was electrified at the time that I had a ſlender braſs wire in my hands, and the ſhock was ſo great that it broke the wire into two pieces and hurt both hands. I then thought of trying it with a thicker wire, and after a more ſecure manner: for this purpoſe I fixed a piece of leather round each wriſt, and faſtened a wire about the thickneſs of a very ſlender knitting-needle to each leather. I then with one hand took hold of the covering of the vial when it was ſtrongly electrified, and with the other I approached the wire in the vial: on doing this there iſſued a very violent

lent ſhock or convulſion of the muſcles of my arms and body, and the wire which was faſtned to the two leathers was broke aſunder about three inches from the middle. The length of the wire from wriſt to wriſt was about fourteen inches.

Upon rubbing with my hand a glaſs globe which was turned round on its axis, I have at different times been affected with a very violent head-ach, which always went off upon diſcontinuing the rubbing of the globe, and quitting the room.

I have met with many perſons who complained that they have found an unuſual pain to continue for ſome days after receiving the ſhock.

I have been aſſured from ſeveral perſons who made the experiments, that the electrical ſhock has been of great ſervice in removing diſorders, particularly fixed rheumatic pains; but I cannot ſay that it was of any remarkable ſervice in four or five caſes of the ſame kind where I tried it.

An account has lately been read to the *Royal Society* of a boy who had been ſeized very ſuddenly with a total blindneſs: he continued ſo five days, and upon being electrified for ſeveral days afterwards, recovered his ſight, and now ſees perfectly well. He had a bliſter on when the experiments were firſt made, which was not thought of till a day or two after, and then it was almoſt

dried up. This case is attested by several persons of credit, and dated at *Dorchester*, *Dec.* 11, 1751.

Miscellaneous Experiments.

Experiment I.

TWO pendulums of equal lengths suspended on the same horizontal line, which was about seven feet from the floor of the room, were made both to vibrate at the same time. Upon electrifying one of them, I observed that the pendulum which was electrified vibrated quicker than the other which was not, and still more so, the nearer the ball of the pendulum was to a non-electric body which was not electrified.

Experiment II.

Having filled a vessel with water, and immerged one end of a siphon therein, I set the vessel upon wax and covered it with a glass receiver, the sides of which were moistened with water to render it non-electric. I then electrified the receiver and siphon, and found, that, while the siphon was covered with the receiver, the water did neither flow faster out, nor spread to a greater distance than it did when they were not electrified. But upon taking away the receiver, the water immediately spread to a considerable distance.

N. B. This

N. B. This laſt experiment may ſerve to ſhew that the motion of the blood is not increaſed by electrifying the animal. For the veſſel and ſiphon covered with the receiver may be looked upon in nearly the ſame light with the body of the animal, the fleſh and ſkin covering the veins and arteries as the glaſs receiver does the ſiphon; and in both caſes the ſurrounding bodies being non-electrics. When the glaſs is taken away, the water ſpreads, from the great tendency the electric matter in the water has to paſs into the adjacent non-electrics which are not electrified. And for the ſame reaſon, the blood, upon being electrified, will, when a veſſel is opened, ſpread to a greater diſtance.

Experiment III.

I have been able by ſtriking ſolid bodies together very briſkly, to produce a light reſembling that produced by the electric matter, nay, even by ſtriking my hands one againſt the other when they were very dry, I have produced a faint bluiſh light, which diſappeared almoſt the inſtant the ſtroke was over. But for this laſt experiment it is neceſſary that the room ſhould be very dark, and that the perſon ſhould be ſome time in the room before he trys it, that the pupil of his eyes may be ſufficiently dilated.

Experiment IV.

If a tube of glaſs and a bar of iron be electrified, the one by friction and the other by the cylinder, to ſuch a degree as that each of them ſhall move a light body from the ſame diſtance; the glaſs tube will retain electric matter longer than the bar, as appears from the light bodies continuing to be moved for a longer time towards the tube than towards the bar.

The glaſs tube, when electrified, muſt be either laid upon or ſuſpended by electrics.

Experiment V.

When the bar is electrified, if a perſon ſtanding on the earth touches very lightly with one hand a non-electric, at the ſame time that his other hand approaches the electrified bar, he will not only feel a ſmart ſenſation in the hand next the bar, but alſo in the hand touching the non-electric. If one, two, three, or more perſons at the ſame time touch very lightly with their fingers different parts of this perſon, and one two, three, or more perſons at the ſame time touch lightly different parts of theſe perſons, and continue to do ſo when the firſt mentioned perſon approaches the bar; immediately on his cauſing the exploſion from the bar they will all feel a ſmart ſenſation, but none will feel it ſo ſtrong as the perſon who cauſes

cauſes the exploſion. In this experiment all the perſons concerned are to ſtand upon the earth. See page 15, and propoſition xii.

EXPERIMENT VI.

I SET a glaſs tube open at both ends, which was about twenty-four inches long, and three inches wide, upon an air-pump; the uppermoſt end was covered with a plate of metal and leathers: a moveable wire about twenty inches long was put through this plate in a collar of leathers, and at the end of this wire within the tube was ſuſpended a braſs ball. Then after having exhauſted the tube and electrified the coated vial, the wire which paſſed into the vial was brought near to the moveable wire in the plate, at the ſame time that a chain communicated with the outſide covering of the vial and the top of the air-pump. On doing this, it ſeemed as if part of the electric matter which was accumulated in the vial, paſſed out of it and through the diſſipator; though the diſtance of the braſs ball from the bottom was about twelve inches. For the experiment being made in the dark, a light was ſeen to dart in rays from the ball towards the air-pump.

EXPERIMENT VII.

THIS laſt experiment was repeated, and a perſon made part of the circuit without receiving the convulſive ſhock.

EXPERIMENT VIII.

UPON lowering the ball no change appeared, except that the light within the glass seemed a little brighter.

EXPERIMENT IX.

WHEN the ball was raised twenty or fifteen inches, there was no light within the glass.

EXPERIMENT X.

ON letting in part of the air, and trying all these experiments over again, no light was seen in the glass, nor did it appear that any electric matter escaped out of the vial upon compleating the circuit in the manner we have now been mentioning. See page 84 and 85.

I DESIRED a friend of mine, who has made the new kind of air-pump which I have mentioned before, and to whom I owe the contrivance of the electric machine represented in the first figure, to try what would be the effects in an electrified glass when the air was exhausted; and the account he has transmitted to me of the experiment is as follows.

A GLASS whose length was about one foot, and greatest diameter eight inches, open at both ends, had one of its ends closed by a brass ferril, which constituted one of the centers on which it turned: the other end was closed with a metal plate: in the center of this plate was a square stem, which was applied

plied to the arbor of a lath by which the glaſs was turned round. On one ſide of this laſt plate was fixed a cock, by means whereof the glaſs was ſcrewed upon the air-pump.

Upon rarifying the air within the glaſs about five hundred times, and afterwards turning the glaſs in the lath, whilſt at the ſame time it was rubbed with my hand, a conſiderable quantity of lambent flame, variegated with all the colours of the rainbow, appeared within the glaſs under the hand: this light was pretty ſteddy in every reſpect, except that every part of it was perpetually changing colour. When a little air was let into the glaſs, the light appeared more vivid and in a greater quantity, but was not ſo ſteddy, for it would frequently break out into a kind of corruſcations like lightning, and fly all about within the glaſs. When a little more air was let in, this flaſhing was continual, and ſtreams of bluiſh light ſeemed to iſſue from under my hand within the glaſs in a thouſand forms with great rapidity, and appeared like a caſcade of fire. Sometimes it ſeemed to ſhoot out into the forms of trees, moſs, &c. When more air was let in, the quantity of light was diminiſhed, and the ſtreams compoſing the flaſhes narrower. The glaſs now required a greater velocity and harder friction. Theſe circum-

ſtances

ſtances increaſed as more air was let in: ſo that by ſuch time as the glaſs was one third full of air, theſe corruſcations quite vaniſhed, and a much ſmaller quantity of light appeared partly within and partly without the glaſs. And when all the air was let in, the light appeared wholly without the glaſs, and much leſs in quantity than when the glaſs was in part exhauſted.

EXPERI-

EXPERIMENTS

UPON

Artificial Magnets.

MR. *Boſe*, profeſſor at *Wittemburgh*, in a letter to the Royal Society in *London*, gave an account that he had been able, by the effects of electric matter meerly, to invert the poles of natural magnets, deſtroy their virtue intirely, and give it again *de novo*: but did not take notice of the method he made uſe of for that purpoſe: nor have I yet heard of any one perſon who has ſucceeded in the making of theſe experiments.

As I did not think it impoſſible that ſome change might be made in the powers of magnets by the electric matter, I was induced to try ſeveral experiments of this ſort. And tho' I did not obſerve any remarkable change, I thought an account of the ſeveral experiments would not be unacceptable in this Treatiſe.

THE

THE magnets I uſed in the following experiments were made by Dr. *Knight*, each of them about eight inches long.

EXPERIMENT I.

HAVING obſerved the greateſt weight each of them could lift, which was nearly equal, I ſuſpended one of them by a thread fifteen inches long to the end of the bar B B, with the north pole uppermoſt, and cauſed the wheel to be turned twenty minutes. On taking it from the thread, I found that it raiſed the ſame weight it did before it was electrified.

EXPERIMENT II.

I THEN ſuſpended the ſame magnet again, but with the ſouth pole uppermoſt, and after it had been electrified for the ſame length of time, I removed it from the thread, and found that it raiſed the ſame weight.

EXPERIMENT III.

BY holding the north end of one of the magnets near a braſs globe ſuſpended by the electrified bar, I cauſed ſeveral exploſions between the magnet and globe; and on taking it away, I did not find any alteration made in its power.

EXPERIMENT IV.

UPON repeating the experiment with the ſouth pole next the globe, no viſible alteration enſued.

Experiment V.

I set the vial with the filings, after they were ſtrongly electrified, upon wax, and then taking one of the magnetic bars in my hand, I made the north pole approach the wire in the vial at the ſame time that I touched a braſs wire faſtened to the outſide covering of the vial with the ſouth pole: ſo that in this caſe the magnetic bar was the diſſipator. And on doing this a large exploſion inſued, by which the greateſt part of the electric matter accumulated in the filings was diſſipated. I repeated the experiment ſeveral times, and could not find upon examining the power of the bar, that it had undergone any change, either with reſpect to its polar or magnetic virtue.

Experiment VI.

I repeated the ſame experiment an equal number of times, with the ſouth pole uppermoſt, and did not find any ſenſible change in the magnet.

Experiment VII.

I suspended the ſame bar again with the north pole uppermoſt, and then brought a thin plate of glaſs, which was laid on the palm of my hand, into contact with the ſouth pole of the magnet, and there continued holding it whilſt the wheel was continually turned for near thirty minutes. On my taking away the magnet

magnet, and trying its ſtrength, I found no variation, nor indeed any alteration in its poles.

EXPERIMENT VIII.

I REPEATED the experiment with the ſouth pole of the magnet uppermoſt, and the ſucceſs ſeemed to be the ſame.

EXPERIMENT IX.

AFTER ſuſpending the ſame bar again in thread to the electrified bar, I brought very fine filings of iron near it, and obſerved that the filings did not adhere to the bar ſo ſtrongly as when it was not electrified.

EXPERIMENT X.

INTO a vial filled with quickſilver and covered on the outſide with lead, I put one of the magnetic bars inſtead of the crooked wire w, the north pole of the magnet being without the neck of the vial. After electrifying the vial for a conſiderable time, I found that the magnet had neither loſt nor gained ſtrength.

EXPERIMENT XI.

UPON repeating the experiment with the ſouth pole, no alteration was obſerved.

EXPERIMENT XII.

I THEN put the ſame bar into the vial with the north pole out as before, and when the quickſilver and magnet were ſtrongly electrified, I brought the end of a diſſipator made of

brass near the bar, and caused an explosion. I repeated this experiment about forty times, and, upon examining the power of the magnet, I perceived little or no alteration; the difference, if any, was a diminution of its virtue.

Experiment XIII.

I repeated the experiment with the other bar, the south pole being without, and, so far as I was able to observe, there did not appear to be any remarkable difference.

Experiment XIV.

The vial and bar being electrified as in the former experiment, instead of making use of a piece of brass to cause the explosion, I used one of the magnets as a dissipator, and placed the south pole of one near to the north pole of the other, with a piece of brass eight inches long between the poles, to prevent them acting upon one another. And to prevent the magnet which was without the vial from being affected by the bar within, and the iron wire surrounding the vial, there was another piece of brass eight inches long in contact with the covering of the vial, and the other pole of the magnet. On electrifying the vial, and causing several explosions, I found that both the magnetic bars retained nearly their former virtue.

Mr. Franklyn has sent an account, which was read at the *Royal Society* very lately, that he

he has melted points of needles, which were very fine, with the electric explosion. That these needles would at the same instant acquire a certain degree of magnetism; and that their polarity would be according to the situation of the needles at the time of making the experiment.

Now as we have had frequent instances of iron acquiring this amazing property in a moment from lightning, this is no small confirmation of what Mr. *Franklyn* has advanced concerning the affinity between the effects of lightning and electricity.

The END.

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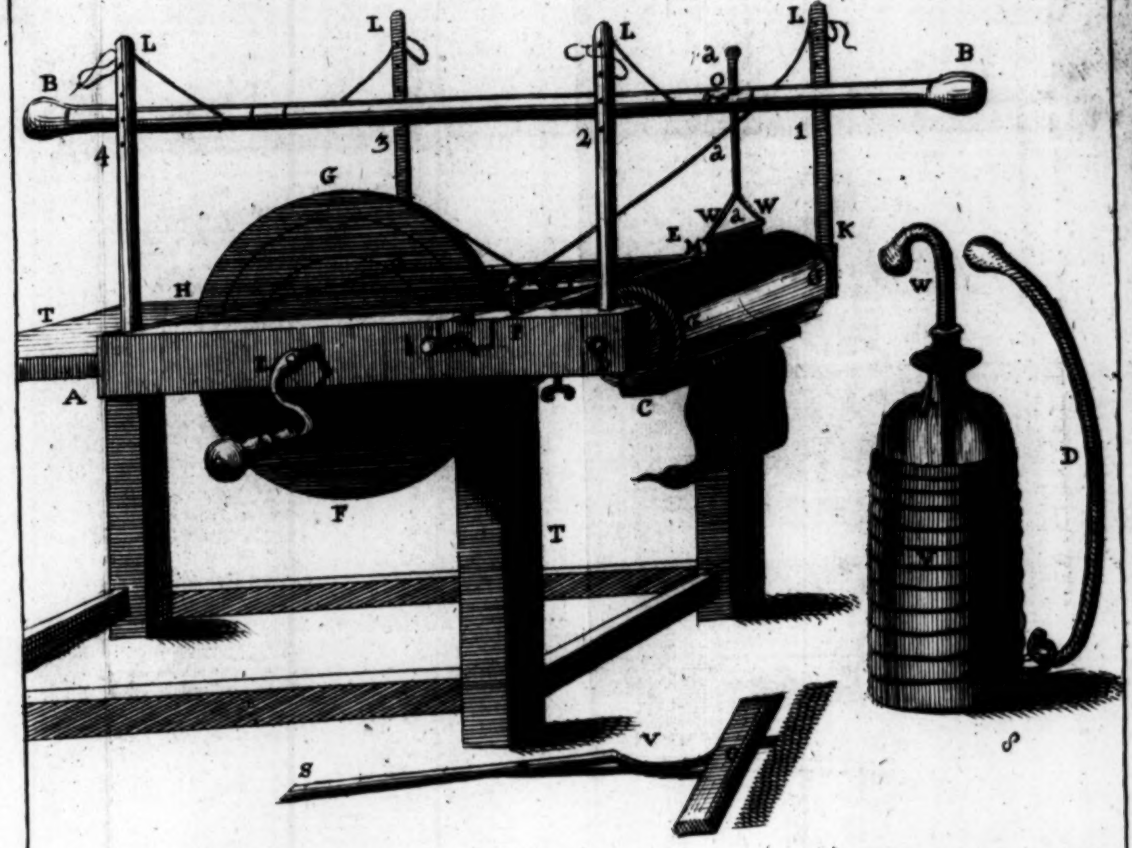
Fig. 1.



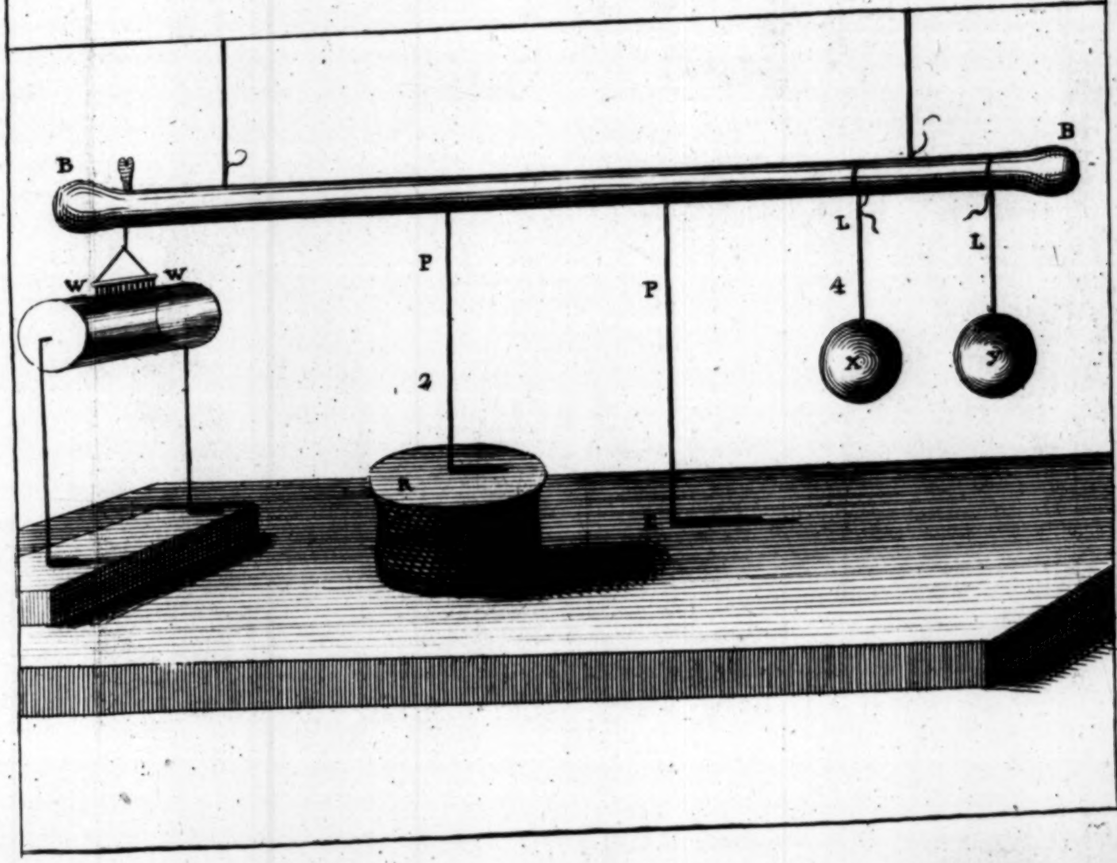


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Fig. 3.

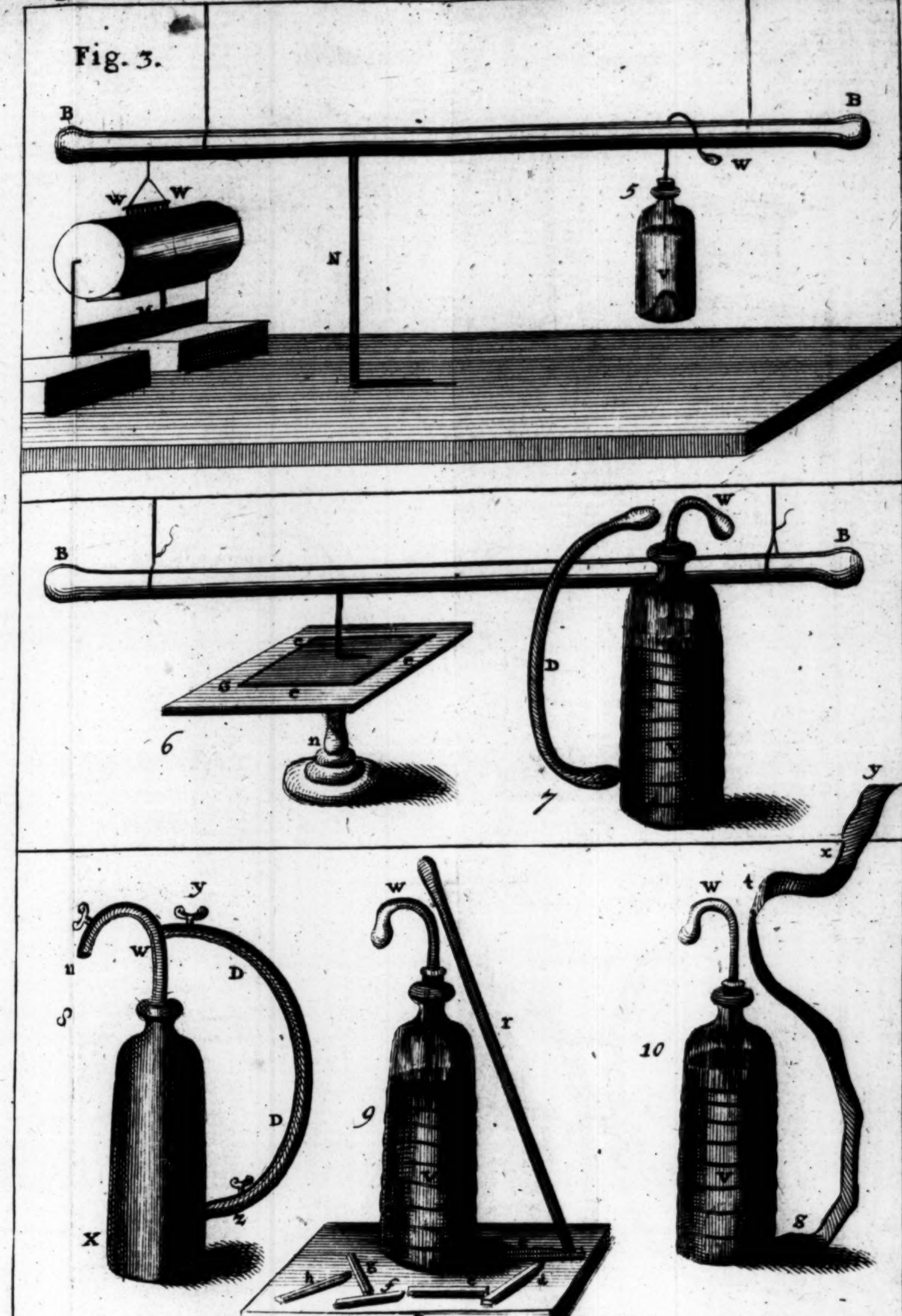

Fig. 12.

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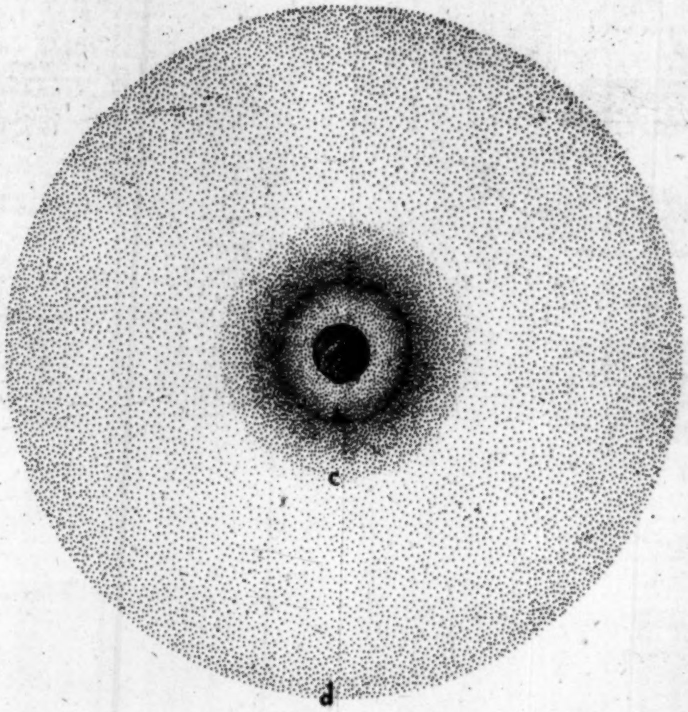

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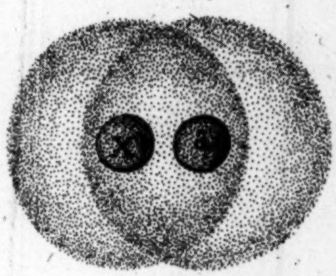

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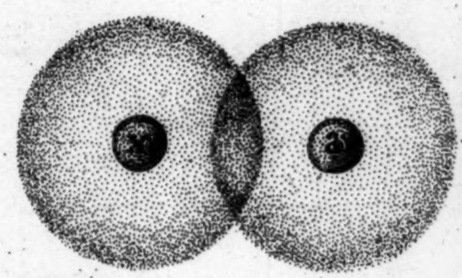

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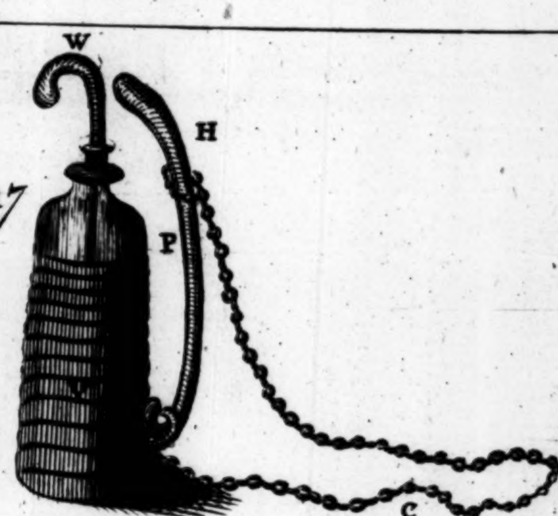

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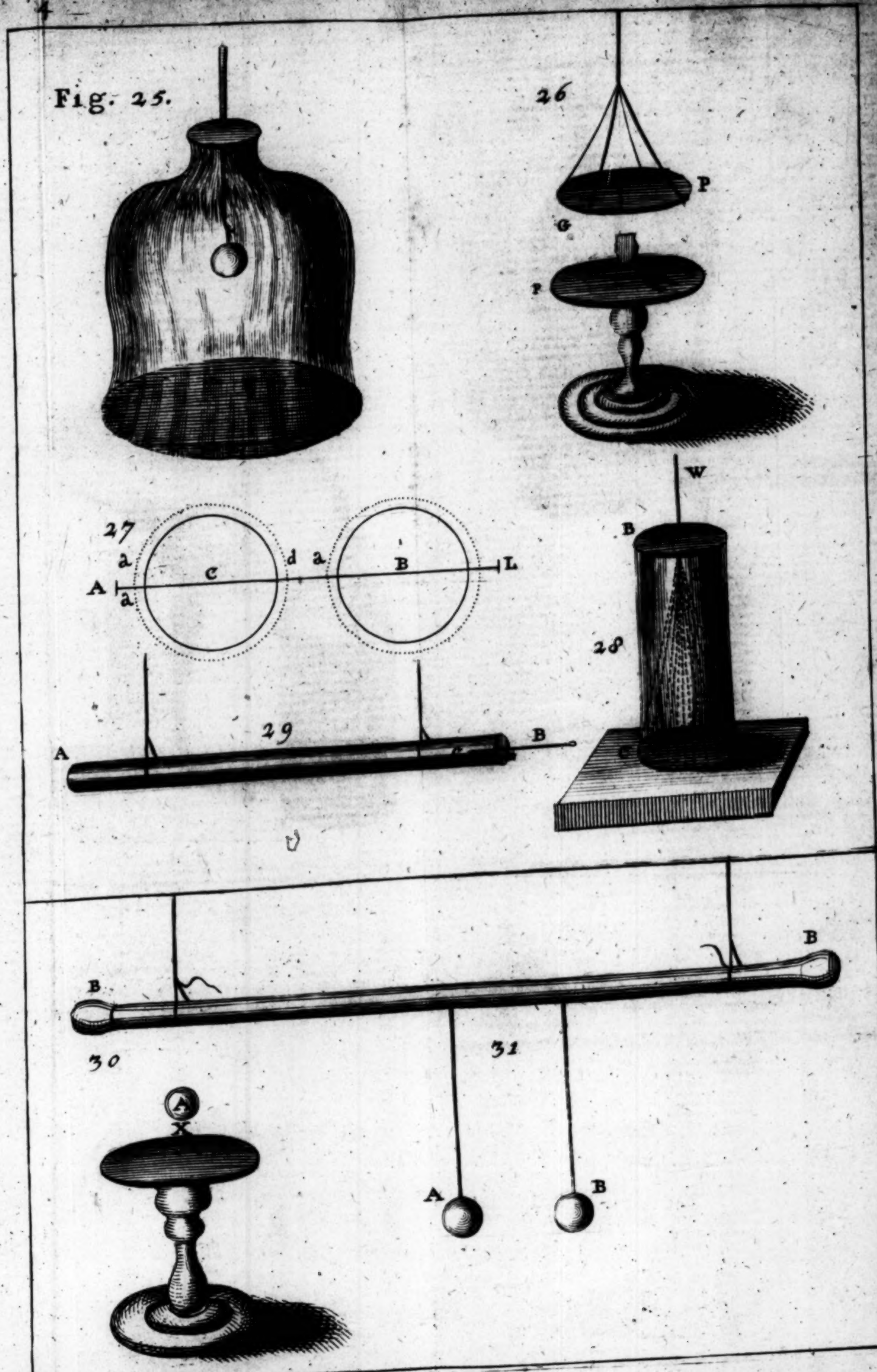

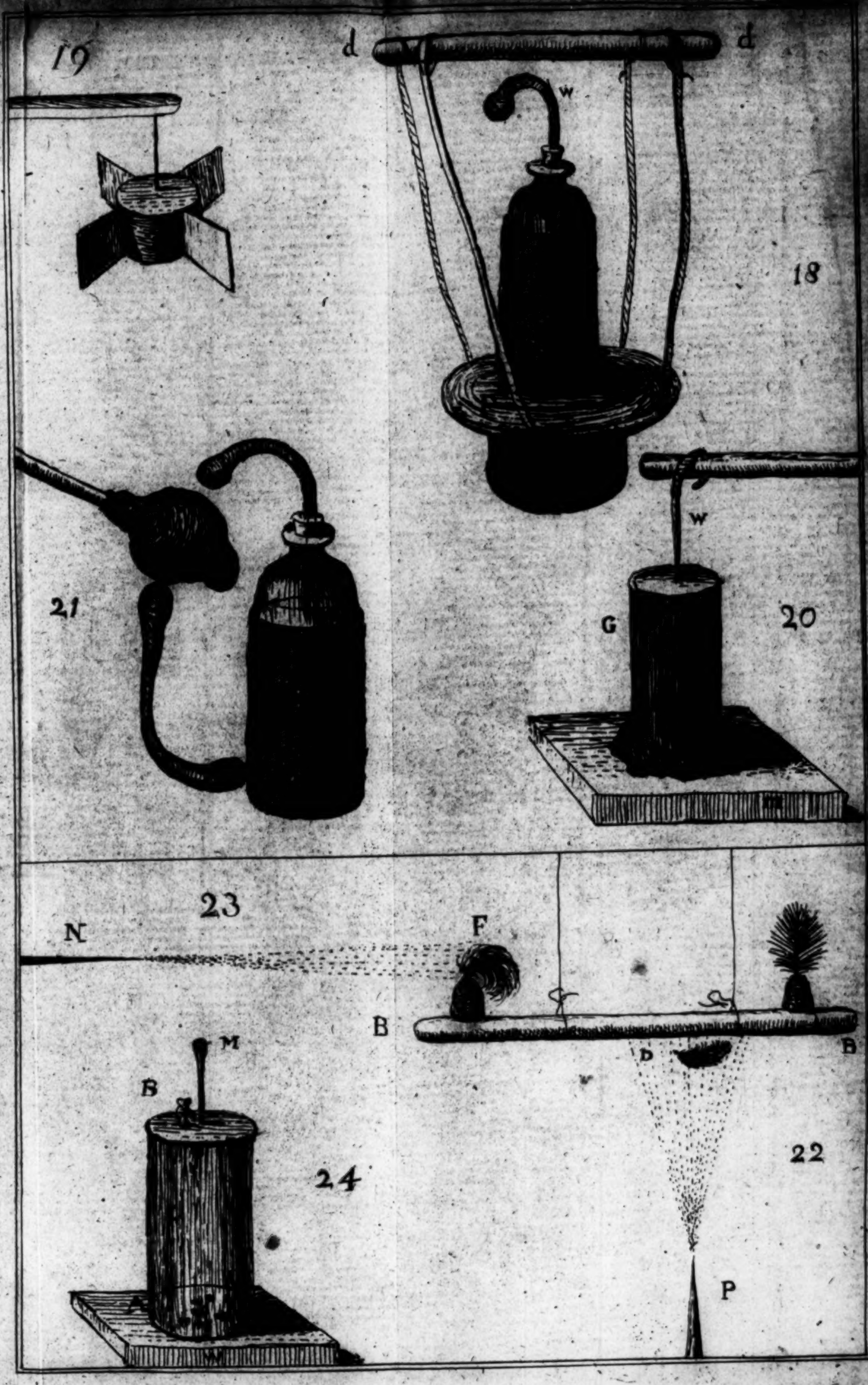
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